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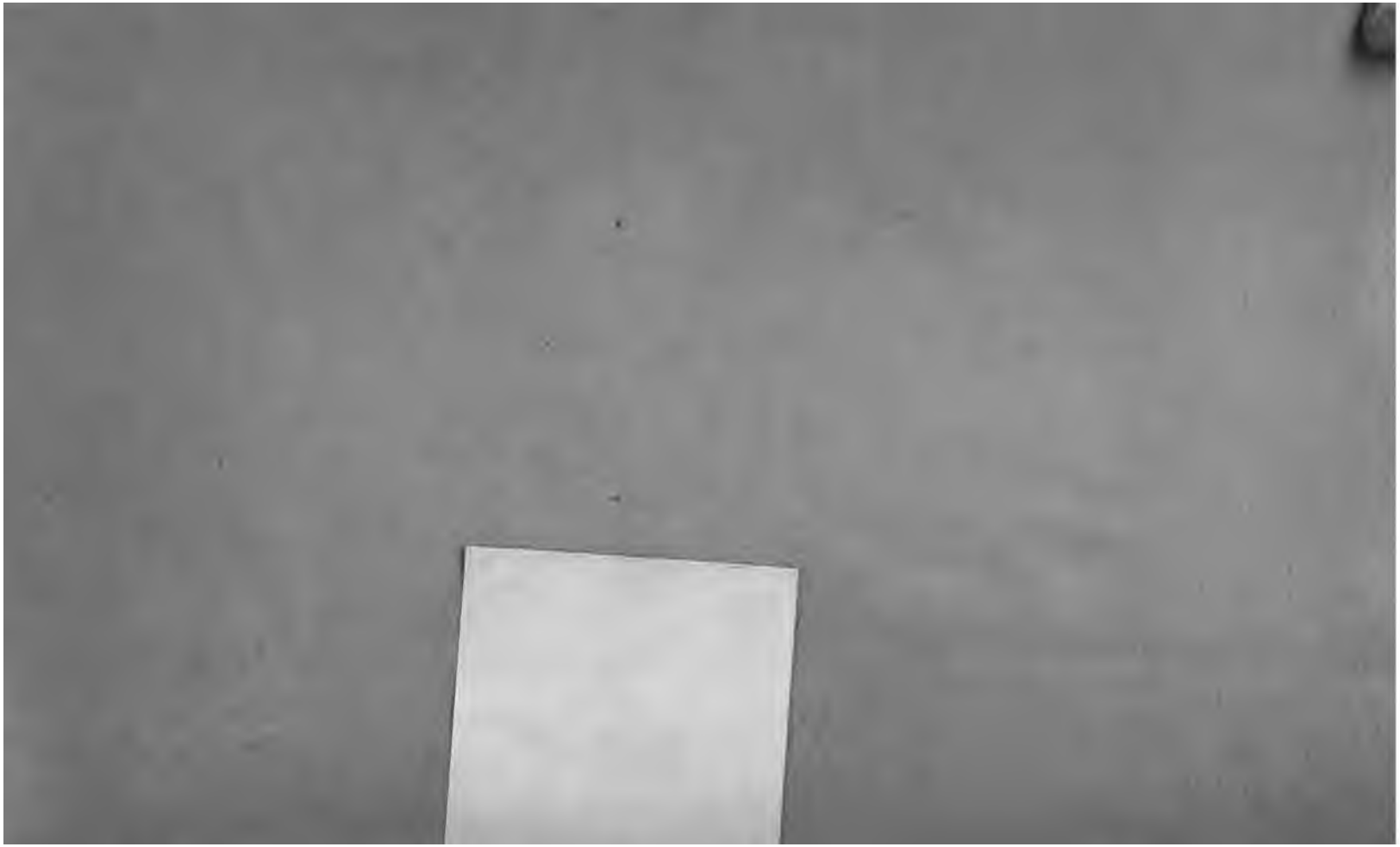

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UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

RESULTS

OF

PIRIT LEVELING IN PENNSYLVANIA

FOR THE

YEARS 1899 TO 1905

INCLUSIVE

BY

S. S. GANNETT AND D. H. BALDWIN

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RESULTS OF SPIRIT LEVELING IN PENNSYLVANIA FOR THE YEARS 1899 TO 1905, INCLUSIVE.

By S. S. GANNETT and D. H. BALDWIN.

INTRODUCTION.

The readjustment in 1903 of the precise-level net in the eastern portion of the United States by the United States Coast and Geodetic Survey necessitated a corresponding readjustment of all spirit-level heights of the United States Geological Survey dependent thereon. These results will be summarized by States or groups of States and published from time to time in bulletin form.

All results of leveling in Pennsylvania previously published in Appendixes to Reports of the Director of the United States Geological Survey and in Bulletin No. 185, as well as levels not previously published, have therefore been readjusted, rearranged by quadrangles, and collected herewith in one publication. Additional work done in 1902 on Sideling Hill quadrangle, Fulton County, will be reported on when the work in that quadrangle is completed. Descriptions and elevations of bench marks are given in forty-two counties, furnishing vertical control for one-fourth of the total area of the State.

The field work was done under the direction of Mr. H. M. Wilson, geographer, and under the immediate supervision of Messrs. Frank Sutton and R. D. Cummin, chiefs of section, United States Geological Survey, in cooperation with the State of Pennsylvania, by various topographers and levelmen of the United States Geological Survey, to whom due credit is given under the different headings listed in the following pages. The office work of adjustment was principally done by Mr. D. H. Baldwin, topographer, under the supervision of Mr. S. S. Gannett, geographer in charge of the triangulation and computing section.

The elevations are arranged according to the degree of accuracy of their determination, precise and primary. The former are determined by lines of levels run either in both forward and backward directions or by simultaneous double-rodded lines, a high-grade instrument being used and special precautions being taken in observations and reduction to correct errors and make the line continuously good throughout. The latter or primary levels are determined with the Y level, precautions being taken against only the principal errors and the levels being run mostly in circuits of single lines. The allowable limit of error observed on the precise work already done by the Geological Survey in this State is represented in feet by $0.03\sqrt{D}$ and that for the primary work by $0.05\sqrt{D}$, in which D is the length of circuit in miles.

The bench marks described in the following list are of two general forms. First, a circular bronze or aluminum tablet 3½ inches in diameter and one-fourth inch thick, appropriately lettered, having a 3-inch stem cemented into a drill hole, generally in the vertical walls of public buildings, bridge abutments, or other substantial masonry structures. The second form, employed where masonry or rock is not accessible, consists of a hollow wrought-iron post 4 feet in length and 3½ inches in outer diameter, split at the bottom and expanded to 12 inches, so as to prevent both the easy subsidence of the post and its being maliciously pulled out of the ground. The iron is heavily coated with asphalt, and over the top of the post is riveted a bronze tablet similar to that described above.

The numbers stamped upon the bench marks as described in the following lists represent the elevations to the nearest foot above mean sea level, as determined by unadjusted levels in the field. They have been subjected to changes resulting from the adjustments necessary to close circuits and to those resulting from reduction to mean sea level through readjustment of the precise-level net of the United States. In some cases the finally accepted elevations as printed herein differ from those submitted as bench-mark numbers by 1 or 2 feet. This method of numbering bench marks has been adopted where many levelmen are working in the same area at the same time, as less liable to lead to confsuion in identification of bench marks than any attempt at serial numbering, and because the bench-mark number at the same time gives an approximate statement of the elevation. It is assumed that engineers and others finding these bench marks so stamped in the field will communicate with the Director of the United States Geological Survey in order to obtain the accepted elevation to hundredths or thousandths of a foot.

Any person finding bench marks in the following lists mutilated or destroyed will confer a favor by notifying the Director, United States Geological Survey, Washington, D. C.

PRECISE LEVELING.

PIKE AND SUSQUEHANNA COUNTIES.

GREAT BEND, LACKAWAXEN, AND NARROWSBURG QUADRANGLES.

The elevations in the following list are the result of a line of precise levels run from Binghamton to Poughkeepsie. The two sections of this line, Binghamton to Hancock, and Hancock to Poughkeepsie, form two links in the net of precise leveling in the United States, 49 and 138 miles in length, respectively. The elevations here reported are the result of the 1903 adjustment, the effect of which upon the original results by this line has been to increase the elevation at Hancock with respect to Binghamton 0.042 foot and increase the elevation at Poughkeepsie with respect to Hancock 0.423 foot.

The New York portion of this line is published in the bulletin of spirit leveling for the State of New York (Bull. 281, U. S. Geol. Survey). The leveling was done during June, July, and August, 1900, by Mr. C. H. Semper, levelman. The standard bench marks are stamped "ALBANY" in addition to the figures of elevation.

GREAT BEND QUADRANGLE.

GREAT BEND, ALONG ERIE RAILROAD, TO LANESBORO.

	Feet.
Great Bend, at milepost J. C. 200 D. 224, north-bound track; top of rail	879.9
Great Bend, 200 feet north of station, in face of southeast foundation stone of railroad water tank; bronze tablet stamped "880 ALBANY 1900"	880.778
Hickory Grove, 600 feet north of station, top of southeast abutment of iron bridge; bronze tablet stamped "893 ALBANY 1900"	893.621
Hickory Grove, in front of station, north-bound track; top of rail	896.0
Susquehanna, in front of station, north-bound track; top of rail	909.9
Lanesboro, 1.3 miles northeast of Susquehanna, long iron bridge over highway and stream, top of south abutment, west side; bronze tablet stamped "955 ALBANY 1900"	956.139

NARROWSBURG QUADRANGLE.

MASTHOPE, ALONG ERIE RAILROAD, TO WESTCOLANG.

Masthope, in front of station, north-bound track; top of rail	667.5
Westcolang Park, 100 feet east of station, railroad bridge, top of west abutment, south side; bronze tablet stamped "665 ALBANY 1900"	665.618

LACKAWAXEN QUADRANGLE.

LACKAWAXEN TO MILLRIFT.

	Feet.
Lackawaxen, in front of station, north-bound track; top of rail	646.8
Shohola, between Shohola Glen and store, stone steps opposite east end of station, third from bottom; bronze tablet stamped "648 ALBANY 1900"	648.992
Parkersglen, in front of station, north-bound track; top of rail	626.5
Pond Eddy, in front of station, north-bound track; top rail	570.8
Pond Eddy, 0.2 mile east of; 350 feet east of whistle post, cut on south side of railroad, face of rock; bronze tablet stamped "573 ALBANY 1900"	574.233
Millrift, in front of station, north-bound track; top of rail	494.4
Millrift, 0.3 mile east of, long bridge over Delaware River, top of west abutment, south side; bronze tablet stamped "491 ALBANY 1900"	491.874

BRADFORD AND LYCOMING COUNTIES.

GILLETT, GROVER, HALSTON, TROUT RUN, AND WILLIAMSPORT QUADRANGLES.

The elevations in the following list are the Pennsylvania portion of the line of precise leveling run south from Elmira, N. Y., a point on the precise-level line of 1898, and connected at Williamsport, Pa., to a circuit of Pennsylvania Railroad levels from Harrisburg. The latter point is on the Coast and Geodetic Survey transcontinental precise line. This line, 75 miles in length, was involved as a factor in the 1903 adjustment of the precise-level net, the result of which was to lower the elevation by the original line only 0.004 foot at Williamsport with respect to Elmira.

The usual method of leveling and party outfit was used. The leveling was done in 1899 by Mr. C. H. Semper, levelman in charge. The standard bench marks on this line are stamped with the letters "HARRISBURG" in addition to figures of elevation and the year 1899. The elevations stamped are mostly 1 foot too low, due to an error of about 0.7 foot in the originally accepted elevation at Elmira, and thus do not strictly accord with the reference mark at Harrisburg, an aluminum tablet stamped "364 HARRISBURG 1899," in the State Library, the elevation of which is accepted as 363.988 feet above mean sea level.

GILLETT QUADRANGLE.

NEW YORK-PENNSYLVANIA BOUNDARY POST, ALONG NORTHERN CENTRAL RAILROAD TO TROY.

	Feet.
State boundary (N. Y.–Pa.), opposite line post; top of rail	1,096.7
Fassett, at road crossing near station; top of rail	1,122.9
Gillett, in front of station; top of rail	1,201.7
Dunning, in front of station; top of rail	1,237.5
Snedikar, 50 feet west of railroad, in foundation wall of store and railroad station; bronze tablet stamped "1265 HARRISBURG 1899"	1,265.229
Columbia crossroads, in front of station; top of west rail	1,130.7
Columbia crossroads, 1.8 miles south of, top of north wall of culvert and cattle pass, west side of railroad; bronze tablet stamped "1099 HARRISBURG 1899"	1,099.855
Troy, road crossing at cemetery; top of east rail	1,074.6
Troy, in front of station; top of west rail	1,136.1
Troy, 0.2 mile south of station, north side of railroad water tank, in top of coping stone of foundation; bronze tablet stamped "1139 HARRISBURG 1899"	1,139.758

GROVER QUADRANGLE.

COWLEY TO ROARING BRANCH.

Cowley, main track, in front of station; top of east rail	1,358.5
Cowley, 0.5 mile south of, in top of coping stone of railroad creek culvert on east side of railroad; bronze tablet stamped "1358 HARRISBURG 1899"	1,358.847
Canton, main track, front of station; top of rail	1,255.2
Canton, 0.4 mile south of, in south abutment of old railroad bridge masonry, 20 feet east of railroad; bronze tablet stamped "1246 HARRISBURG 1899"	1,246.334
Cedar Lodge, at railroad crossing near station; top of rail	1,204.8
Grover, in front of station; top of rail	1,229.4
Penbryn, in front of station; top of east rail	1,223.5
Roaring Branch, 600 feet north of station, east abutment of steel highway bridge, on bridge seat; aluminum tablet stamped "966 HARRISBURG 1899"	966.236
Roaring Branch, in front of station; top of rail	959.3

RALSTON QUADRANGLE.

RALSTON TO MARSHHILL.

	Feet.
Ralston, 0.2 mile north of station, in south abutment, west side of railroad bridge; bronze tablet stamped "851 HARRISBURG 1899"	852.116
Marshhill, in front of station; top of west rail	795.9

TROUT RUN QUADRANGLE.

BODINE TO HEPBURNVILLE.

Bodine, in front of station; top of rail	760.5
Fields, 0.1 mile north of, in south abutment east side of iron railroad bridge; bronze tablet stamped "732 HARRISBURG 1899"	732.512
Gray, at north end of switch, at road crossing; top of west rail	717.0
Trout Run, in front of station, main track; top of rail	677.9
Powys, in front of station; top of rail	629.7
Powys, 0.7 mile south of, in northwest wing abutment of small creek culvert; aluminum tablet stamped "620 HARRISBURG 1899"	620.554
Cogan Valley, in front of station; top of rail	598.7
Hepburnville, at road crossing near station; top of rail	582.9

WILLIAMSPORT QUADRANGLE.

AT WILLIAMSPORT.

Williamsport, general superintendent's office building, north side of east entrance, on water table; chiseled shelf (Pennsylvania Railroad bench mark, elevation 528.35)	528.50
Williamsport, northwest corner base of Soldiers' monument; chiseled square (Pennsylvania Railroad bench mark No. 46, elevation 525.04)	525.19
Williamsport, city hall, in front face near main entrance; aluminum tablet stamped "528 HARRISBURG 1899"	528.266

WARREN COUNTY.

KINZUA, WARREN, AND YOUNGSVILLE QUADRANGLES.

The elevations in the following list are the Pennsylvania portion of the result of two independent lines of precise leveling run in opposite directions between Salamanca, N. Y., and Irvineton, Pa. A large probable error occasioned the second running, with a result, however, checking to 0.043 foot the original figures. The final mean results of this line were included as a factor in the 1903 adjustment of the precise-level net. The result of this was to increase the elevation at Irvineton, Pa., by this line 0.128 foot with respect to Salamanca; therefore, there has been distributed a correction of 0.128 foot in a total distance of 48.8 miles in amounts proportional to the mileage. Both lines were run by the same methods and similar party outfits as in previous work, each being a double-rodded, simultaneous, direct and reverse read line, employing special 10-foot double-faced targeted rods. The total divergence in the 1902 line was but 0.011 foot and the total correction 0.085 foot.

The leveling of 1899 was done by Mr. E. L. McNair, topographer, and that of 1902 by Mr. D. H. Baldwin, topographer. The standard bench marks are referred to the Dunkirk datum and stamped with the letters "DUNKIRK" in addition to the figures of elevation and year 1899.

KINZUA QUADRANGLE.

CORYDON, ALONG PENNSYLVANIA RAILROAD, TO TUTTLETOWN.

	Feet.
Corydon, 0.33 mile north of station, at southeast corner of steel bridge over Willow Creek, on foundation coping stone; aluminum tablet stamped "1281 DUNKIRK 1899"	1,281.865
Corydon, in front of station; top of north rail	1,281.2
Corydon, 2.04 miles south of, southeast corner of Bridge No. 758, on foundation coping stone; chiseled square	1,271.25
Gawanga, in front of station; top of rail	1,267.1
Sugar Run, 1.4 miles south of, southwest corner of Bridge No. 114, on foundation coping stone; aluminum tablet stamped "1253 DUNKIRK 1899"	1,254.403
Sugar Run, in front of station; top of south rail	1,244.9

	Feet.
Sugar Run, 0.13 mile south of station, southwest corner of Bridge No. 113, on parapet coping stone; chiseled square	1,245.2)
Kinzua, in front of station; top of south rail	1,237.1
Kinzua, 500 feet south of station, at northwest corner of steel-truss bridge across Kinzua Creek, 2.5 feet west of chord, on foundation coping stone; aluminum tablet stamped "1229 DUNKIRK 1899"	1,230.236
Tuttletown, 400 feet south of, at northeast corner of four-span bridge over Allegheny River, on parapet coping stone; chiseled square	1,232.1

WARREN QUADRANGLE.

GREAT BEND TO IRVINETON.

Great Bend, at flag crossing; top of south rail	1,222.7
Great Bend, 0.80 mile southwest of, northeast corner of Bridge No. 644, on foundation stone; chiseled square	1,221.2
Hemlock, at flag crossing; top of rail	1,208.4
Hemlock, 0.2 mile southwest of, at northwest corner of steel-girder Bridge No. 110, 5 inches from bed plate, on foundation coping stone; aluminum tablet stamped "1205 DUNKIRK 1899"	1,205.768
Glade, in front of station; top of southeast rail	1,199.2
Struthers, in front of station; top of north rail	1,191.9
Warren, 300 feet south of station, at northwest corner of double-track steel-truss Bridge No. 54 over Allegheny River, on coping of parapet wall; aluminum tablet stamped "1193 DUNKIRK 1899"	1,193.485
Warren, at station, Pennsylvania Railroad bench mark No. 33, in doorsill of waiting room; copper plug	1,194.813
Starbrick crossing; top of south rail	1,189.5
Jackson crossing, 650 feet east of, Pennsylvania Railroad bench mark No. 37, southwest corner of Bridge No. 53, coping stone; copper plug	1,180.778
Jackson crossing; top of south rail	1,181.5
Irvineton, 1.48 miles east of, Pennsylvania Railroad bench mark No. 38, southwest corner of small girder Bridge No. 52, top of second step from top of wing wall; copper plug	1,166.172

YOUNGSVILLE QUADRANGLE.

NEAR IRVINETON.

Irvineton, 0.75 mile east of, Pennsylvania Railroad bench mark No. 39, southeast corner of open drain, on foundation stone; copper plug	1,168.951
Irvineton, 0.24 mile east of station, east abutment of double-track steel-girder Bridge No. 50 across Brokenstraw Creek, north side of middle girder, on foundation coping stone; aluminum tablet stamped "1167 DUNKIRK 1899"	1,167.948

FOREST, VENANGO, AND WARREN COUNTIES.

FRANKLIN, OIL CITY, TIDIOUTE, TIONESTA, AND YOUNGSVILLE QUADRANGLES.

The elevations in the following list are the result of a line of precise levels run from Irvineton to Franklin. The latest adjustment of the precise-level net in which this line was a factor has resulted in raising the original values of the line 0.083 foot at Franklin with respect to Irvineton, distributing this amount over the total distance of 57.9 miles.

The method of leveling and party outfit was similar to that previously used. The leveling was done in 1899 by E. L. McNair, topographer. The standard bench marks are referred to the Dunkirk, N. Y., datum and are stamped with the letters "DUNKIRK" in addition to figures of elevation which are mostly 1 foot low.

YOUNGSVILLE QUADRANGLE.

IRVINETON TO THOMPSON.

	Feet.
Irvineton, 0.24 mile east of station, east abutment of double-track steel-girder Bridge No. 50 across Brokenstraw Creek, north side of middle girder, on foundation coping stone; aluminum tablet stamped "1167 DUNKIRK 1899"	1,167.948
Thompson, 0.12 mile northeast of Western New York and Pennsylvania station, at east end of south abutment of small girder Bridge No. 85A, on coping stone; aluminum tablet stamped "1135 DUNKIRK 1899"	1,136.118
Thompson, in front of station; top of west rail	1,139.8

TIDIOUTE QUADRANGLE.

COBHAM TO JAMISON.

	Feet.
Cobham, in front of flag station; top of east rail	1,131.4
Tidioute, in front of Pennsylvania Railroad station; top of north rail	1,110.5
Tidioute, 100 feet east of station, 270 feet south of center of track at north end of suspension bridge across Allegheny River, on face of west cable anchor; aluminum tablet stamped "1116 DUNKIRK 1899"	1,116.93[illegible]
Trunkeyville, in front of flag station; top of east rail	1,096.0
Trunkeyville, 350 feet south of flag post, 45 feet west of center of main track, 4.5 feet south from large chestnut tree, in large bowlder; aluminum tablet stamped "1098 DUNKIRK 1899"	1,098.647
Hickory, 0.2 mile north of, at northeast corner of steel truss combination railroad and highway bridge across Allegheny River, on foundation wall; aluminum tablet stamped "1086 DUNKIRK 1899"	1,086.578
Hickory, in front of station; top of west rail	1,088.6
Dawson, in front of station; top of east rail	1,073.0
Jamison, in front of flag station; top of east rail	1,070.5

TIONESTA QUADRANGLE.

Tionesta, 180 feet north of station, 70 feet east of main track, at southwest corner of highway bridge across Allegheny River, on coping stone; aluminum tablet stamped "1063 DUNKIRK 1899"	1,064.289
Tionesta, in front of station, main track; top of east rail	1,057.5

OIL CITY QUADRANGLE.

HUNTER TO SEDGWICK.

Hunter, near flag station, at road crossing; top of west rail	1,058.7
Baum, in front of flag station; top of east rail	1,043.9
President 0.3 mile north of flag station, 17.5 feet east of center of track, 2.4 feet below top of rail, top of large bowlder 5 feet high and 12 feet long; aluminum tablet stamped "1042 DUNKIRK 1899"	1,042.636
President, in front of flag station; top of east rail	1,044.8
Eagle Rock, in front of station; top of east rail	1,043.0
Riverview, in front of flag station; top of south rail	1,035.9
Oleopolis, 0.3 mile northeast of flag station, at northwest corner of one-span steel-truss Bridge No. 74, 13 feet north of center of track, on coping stone of abutment wall; aluminum tablet stamped "1030 DUNKIRK 1899"	1,031.339
Oleopolis, in front of flag station; top of south rail	1,208.1
Walnut, in front of flag station; top of east rail	1,020.6
Rockwood, in front of flag station; top of west rail	1,013.4
Sneily, in front of flag station; top of east rail	1,006.6
South Oil City, 0.4 mile east of railroad station, bridge seat at northeast corner of large three-span steel-truss bridge across Allegheny River, 7 feet north of center of track, 5.1 feet below top of rail and 6 inches from end of chord; aluminum tablet stamped "1009 PITTSBURG 1899"	1,009.664
South Oil City, in front of railroad station; top of north rail	1,006.0
Sedgwick, in front of flag station; top of east rail	999.8

FRANKLIN QUADRANGLE.

Prentice, in front of flag station; top of west rail	990.5
Franklin, 60 feet north of north end of station, 90 feet west of center of track, east abutment of highway bridge across Allegheny River, second step below coping stone at end of south wing wall, 3.4 feet above top of rail; aluminum tablet stamped "987 PITTSBURG 1899".	987.777

ALLEGHENY, ARMSTRONG, CLARION, CRAWFORD, ERIE, MERCER, AND VENANGO COUNTIES.

CAMBRIDGE SPRINGS, ERIE, FOXBURG, FRANKLIN, FREEPORT, KITTANNING, McKEESPORT, MEADVILLE, RURAL VALLEY, SHARPSBURG, STONEBORO, AND UNION CITY QUADRANGLES.

The elevations in the following list result from a line of precise levels extending from Erie to Pittsburg, Pa. The initial bench mark is an aluminum tablet stamped "635 ERIE" in the water table of the northwest corner of the hospital wing of the Soldiers' Home, Erie, the elevation of which was previously determined by primary levels to be 58.588 feet above a bench mark of the army engineers, described as a "chisel mark," at southwest corner of foundation of the light-house keeper's dwelling. The line extends south over the Pennsylvania Railroad to Leboeuf, thence over the Erie Railroad to Franklin and from Franklin to Pittsburg over the Allegheny Valley branch of the Pennsylvania Railroad. This line was included in the 1903 adjustment of the precise-level net, and as a result of that adjustment the elevations of the original line with respect to Erie have been lowered 0.204 foot at Leboeuf, 0.499 foot at Franklin, 0.862 foot at West Penn Junction (Lucesco post-office), and Pittsburg. The corresponding distances from Erie are, respectively, 22.4, 76.3, 169.7, and 198.7 miles. Between West Penn Junction and Pittsburg no error was distributed, because of a satisfactory check by Pennsylvania Railroad levels and to simplify the adjustment. The leveling was done in 1899 by Mr. C. H. Semper, levelman, except the portion Franklin to Emlenton, which was done by Mr. E. L. McNair, topographer. Standard bench marks are stamped "PITTSBURG" in addition to the figures of elevation and the year 1899.

ERIE QUADRANGLE.

ERIE, ALONG PENNSYLVANIA RAILROAD, TO SAMSON.

	Feet.
Erie Harbor, army engineers' bench mark, southwest corner of foundation of light-house keeper's dwelling; chisel mark	577.591
Erie, northwest corner of hospital wing of Soldiers Home, in water table; aluminum tablet stamped "635 ERIE"	636.179
Erie, at junction of Pennsylvania and Lake Shore railroads; top of foundation of water tank, marked "685"	685.01
Belle Valley, in front of station; top of rail	1,015.5
Belle Valley, 1.1 miles south of, overhead highway bridge, in north end of east side of foundation of bent; aluminum tablet stamped "1103 PITTSBURG 1899"	1,103.430
Langdon, railroad crossing at station, main track; top of rail	1,134.8
Jackson, in front of station, main track; top of rail	1,229.4
Samson, 0.8 mile south of, north end, east side of railroad bridge No. 8, in top of arch masonry; aluminum tablet stamped "1214 PITTSBURG 1899"	1,215.286
Samson, 0.8 mile south of, Bridge No. 8; copper bolt (Pennsylvania Railroad bench mark No. 85)	1,212.035

UNION CITY QUADRANGLE.

SAMSON TO MILLERS STATION.

Samson, 4.3 miles south of, on Bridge No. 14; Pennsylvania Railroad bench mark No. 82	1,191.014
Waterford, in front of station; top of rail	1,192.3
Leboeuf, 1.5 miles west of, on New York, Pennsylvania and Ohio (Erie) Railroad, in culvert masonry on northwest side of railroad; aluminum tablet stamped "1193 PITTSBURG 1899"	1,194.210
Mill Village, in front of station; top of rail	1,214.3
Millers, in front of station, main track; top of rail	1,169.8
Millers, 0.9 mile southwest of, in top of southwest end of bridge abutment; aluminum tablet stamped "1148 PITTSBURG 1899"	1,148.237

CAMBRIDGE SPRINGS QUADRANGLE.

Cambridge Springs, in front of station; top of rail	1,161.6
Venango, in front of station; top of rail	1,161.1
Venango, 0.8 mile southwest of, in southeast end of bridge abutment; bronze tablet stamped "1128 PITTSBURG 1899"	1,128.717

MEADVILLE QUADRANGLE.

SAEGERSTOWN, ALONG ERIE RAILROAD, TO COCHRANTON.

	Feet.
Saegerstown, in front of station; top of rail	1,114.0
Saegerstown, 0.7 mile south of, in north abutment, east side of railroad bridge; bronze tablet stamped "1109 PITTSBURG 1899" (reported as having been removed)	1,109.236
Meadville, in front of station; top of rail	1,078.6
Meadville, 1.8 miles south of, north end of culvert abutment west side of railroad; bronze tablet stamped "1071 PITTSBURG 1899"	1,072.114
Buchanan, in front of station; top of rail	1,073.3
Shaws, in front of station; top of east rail	1,090.5
Cochranton, 1,000 feet northwest of, in abutment of railroad iron bridge, north end, east side; bronze tablet stamped "1062 PITTSBURG 1899"	1,062.391
Cochranton, in front of station; top of rail	1,062.3

STONEBORO QUADRANGLE.

Carlton, in front of station; top of west rail	1,045.3

FRANKLIN QUADRANGLE.

UTICA, ALONG ERIE RAILROAD, TO FRANKLIN.

Utica, in front of station; top of rail	1,033.6
Utica, 300 feet south of station, in east abutment, north side of highway bridge; bronze tablet stamped "1038 PITTSBURG 1899"	1,038.323
Takitezy, at railroad crossing by station; top of rail	1,017.8
Sugar Creek, 1,200 feet southeast of, in northeast end of abutment of railroad bridge; bronze tablet stamped "1013 PITTSBURG 1899"	1,013.628
Franklin, in northeast corner of belt course of Erie Station; aluminum tablet stamped "989 PITTSBURG 1899"	989.349

FRANKLIN, ALONG PENNSYLVANIA RAILROAD, TO BRANDON.

Franklin, Pennsylvania Railroad station, 90 feet west of center of track, at point 60 feet north of north end of station, in second step below coping-stone at end of south wing wall of east abutment of road bridge across Allegheny River; aluminum tablet stamped "987 PITTSBURG 1899"	987.777
Franklin, in front of Pennsylvania Railroad station; top of west rail	984.3
Cochran, in front of station; top of south rail	978.1
Astral flag station; top of rail	973.8
East Sandy, 650 feet north of station; coping stone of abutment at southwest corner of 2-span steel-truss bridge across Sandy Creek, 1.2 feet below top rail 10.5 feet west of center of track; bronze tablet stamped "970 PITTSBURG 1899"	970.905
East Sandy, in front of station; top of east rail	970.5
Foster, in front of flag station; top of north rail	965.3
Brandon, in front of station; top of south rail	957.5
Brandon, 1.3 miles south of station, face of rock ledge 20 feet southeast of center of track, 3 feet above top of rail, 1,100 feet south of milepost 112; bronze tablet stamped "957 PITTSBURG 1899"	957.715

FOXBURG QUADRANGLE.

KENNERDELL, ALONG PENNSYLVANIA RAILROAD, TO CATFISH RUN.

Kennerdell, in front of station; top of west rail	944.0
Kennerdell, 1.5 miles south of station; 300 feet west of milepost 106, large bowlder 10 feet north of center of track, 2.4 feet above rail; bronze tablet stamped "941 PITTSBURG 1899"	942.373
St. George, 0.3 mile south of, 150 feet south of whistling post, in rock on west side of rail; bronze tablet stamped "925 PITTSBURG 1899"	926.181
Rockland, 0.1 mile south of, in northwest wing of abutment of bridge over small creek, 600 feet south of station on west side of railroad; bronze tablet stamped "919 PITTSBURG 1899"	920.792
Wood Hill, in front of station sign; top of west rail	917.4
Shippingport crossing; top of east rail of middle crossing	913.1
Dotter, 600 feet north of, in north abutment of west wing of railroad bridge; bronze tablet stamped "905 PITTSBURG 1899"	906.125
Dotter, in front of station; top of east rail	910.9
Emlenton, 0.4 mile south of, in wing wall of railroad bridge abutment, south end, west side; bronze tablet stamped "898 PITTSBURG 1899"	899.079

	Feet.
Emlenton, at road crossing at station; top of south rail	901.2
Foxburg, in front of station; top of east rail	891.9
Parker, in top of abutment of road bridge at station, east abutment, south side; bronze tablet stamped "883 PITTSBURG 1899"	884.014
Monterey, in front of station; top of south rail	870.8
Monterey, 900 feet south of station, in bridge abutment, north end, east side; bronze tablet stamped "869 PITTSBURG 1899"	870.043
Upper Hillville, in front of station; top of south rail	863.7
Lower Hillville, in front of station; top of west rail	860.6
Lower Hillville, 1 mile south of, in top of culvert wall of small stream, northeast side; bronze tablet stamped "855 PITTSBURG 1899"	856.387
Catfish Run, in front of station; top of east rail	854.7

KITTANNING QUADRANGLE.

EAST BRADY, ALONG PENNSYLVANIA RAILROAD, TO RIVERVIEW.

East Brady, in east abutment wing wall of steel highway bridge; bronze tablet stamped "852 PITTSBURG 1899"	852.645
Redbank, in front of station; top of west rail	846.2
Redbank, 600 feet south of station; in north abutment of railroad bridge, west side of abutment; bronze tablet stamped "844 PITTSBURG 1899"	844.746
Riverview, in front of station; top of rail	835.4

NEALE, ALONG PENNSYLVANIA RAILROAD, TO ROSSTON.

Neale, on last crossing south of station; top of west rail	805.3
Wick City, crossing at pottery works; top of west rail	805.3
Kittanning, in front of station; top of east rail	806.4
Kittanning, on corner of McKain and Vine streets, public school, northwest corner of front face; bronze tablet stamped "803 PITTSBURG 1899"	803.500
Garrett Run, in front of station; top of west rail	796.1
Manorville, in front of station; top of east rail	796.0
Graff, in front of station; top of west rail	790.4
Ford City, in front of station; top of east rail	784.8
Rosston, in front of station; top of west rail	786.6

RURAL VALLEY QUADRANGLE.

RIMER, ALONG PENNSYLVANIA RAILROAD, TO COWANSHANNOCK.

Rimer, 2 miles south of, in north abutment, west side of iron bridge; bronze tablet stamped "820 PITTSBURG 1899"	820.810
Mahoning, in front of station; top of east rail	818.8
Templeton, in front of station; top of west rail	819.1
Mosgrove, in north abutment, east end of railroad bridge, 900 feet north of station; bronze tablet stamped "806 PITTSBURG 1899"	807.227
Cowanshannock, in front of station; top of east rail	805.4

FREEPORT QUADRANGLE.

LOGANSPORT, ALONG PENNSYLVANIA RAILROAD, TO VALLEY CAMP.

Logansport, in front of station; top of west rail	781.7
Rosston, 0.2 mile south of, in east abutment of bridge over river; bronze tablet stamped "786 PITTSBURG 1899"	785.855
Kelley, in front of station; top of west rail	778.3
White Rock, in front of station, main track; top of east rail	780.6
Donley, in front of station; top of south rail	782.2
West Penn Junction, in foundation of turntable of Pennsylvania Railroad, Pennsylvania Railroad bench mark No. 26; copper bolt stamped "788.85"	788.554
West Penn Junction, in foundation wall of turntable of Pennsylvania Railroad; bronze tablet stamped "788 PITTSBURG 1899"	788.573
Garvers Ferry, in front of station; top of west rail	783.7
McKain, in front of station; top of west rail	776.6
Metcalf, in front of station; top of west rail	773.5
Braeburn, in front of station; top of west rail	759.7
Edgecliff, 1,000 feet south of, in north abutment east side of bridge over creek; bronze tablet stamped "764 PITTSBURG 1899"	763.478
Crag Dell, in front of station; top of west rail	776.2
Valley Camp, in front of station, main track; top of west rail	787.1

SHARPSBURG QUADRANGLE.

ARNOLD, ALONG PENNSYLVANIA RAILROAD, TO SYLVAN.

	Feet.
Arnold, in front of station, main track; top of west rail	786.0
New Kensington, in front of station; top of west rail	775.0
Parnassus, in front of station; top of west rail	763.0
Logans Ferry, in front of station, north-bound track; top of east rail	755.7
Barking, in front of station, south-bound track; top of east rail	759.0
Blacks Run, 300 feet south of Bessemer steel railroad bridge over Allegheny River, in face of stone milepost marked "P 13, O. C. 119-5/10"; bronze tablet stamped "770 PITTSBURG 1899." (Reported as having been removed, though shank still remains)	771.194
Hulton, in front of station; top of east rail	776.6
Oakmont, in front of station; top of west rail	763.6
Edgewater, in front of station; top of west rail	753.6
Verona, in front of station; top of west rail	744.8
Sylvan, in front of station; top of west rail	744.1

M'KEESPORT QUADRANGLE.

SANDY CREEK, ALONG PENNSYLVANIA RAILROAD, TO PITTSBURG.

Sandy Creek, in front of station; top of west rail	744.8
Wildwood, in front of station; top of west rail	745.7
Wildwood, doorsill of west door Pennsylvania Water Company house; copper bolt	748.829
Brilliant, in front of station; top of north rail	746.5
Brilliant, 0.3 mile south of, in wall of small culvert south side of railroad; bronze tablet stamped "745 PITTSBURG 1899"	745.354
Morningside, in front of station; top of north rail	745.8
Pittsburg, in front of Butler Street station; top of west rail	742.9
Pittsburg, in front of Forty-third Street station; top of west rail	730.5
Pittsburg, south side of Allegheny avenue, 15 feet west of Allegheny Valley Railway; top of curbstone, stamped "B. M."	736.621
Pittsburg, Liberty street, south side foundation of Washington Street footbridge; copper bolt (Pennsylvania Railroad bench mark)	743.762
Pittsburg, in foundation of Seventh Avenue Hotel, north side, at main entrance; aluminum tablet stamped "738 PITTSBURG 1899"	738.383

WASHINGTON AND WESTMORELAND COUNTIES.

BROWNSVILLE, MASONTOWN, McKEESPORT, MORGANTOWN, AND UNIONTOWN QUADRANGLES.

The elevations in the following list result from the Pennsylvania portion of a line of precise levels run between Pittsburg, Pa., and Grafton, W. Va. The line as run started from bench mark "M" at Grafton, W. Va., on the transcontinental precise-level line of the Coast and Geodetic Survey, a chisel mark on the coping stone at north end of central pier of railroad bridge over Tygart River, and followed the Baltimore and Ohio Railroad to Leith, near Uniontown, Pa., thence over the Pennsylvania Railroad to Pittsburg. This line was included in the 1903 adjustment of the precise-level net, and as a result of that adjustment the elevation by the original line at Braddock with respect to Grafton has been lowered 0.112 foot in a distance of 142.5 miles. Between Braddock and Pittsburg no error was distributed because of a satisfactory check by Pennsylvania Railroad levels and to simplify adjustment. The leveling was done in 1899 by Mr. E. L. McNair, topographer. Standard bench marks are stamped "PITTSBURG" in addition to the figures of elevation and of the year 1899.

M'KEESPORT QUADRANGLE.

PITTSBURG, ALONG PENNSYLVANIA RAILROAD, TO ELBEN.

	Feet.
Pittsburg, in front of Twenty-eighth Street station; top of south rail	755.6
Benvenue, 0.25 mile west of station, bridge seat at south end of west abutment of girder bridge over Pittsburg Junction Railway tracks; bronze tablet stamped "818 PITTSBURG 1899".	818.184
East Liberty, in front of station; top of west rail	913.7
Fifth avenue, in front of station; top of west rail	919.9

	Feet.
Homewood, in front of station; top of west rail	922.2
Homewood, in doorsill of station; copper bolt (Pennsylvania Railroad bench mark)	923.367
Wilkinsburg, in front of station; top of west rail	922.0
Edgewood, in front of station; top of west rail	922.1
Swissvale, in front of station; top of west rail of west track	921.7
Hawkins, in front of station; top of rail	881.1
Braddock station, in doorsill of door to ladies' waiting room; copper bolt (Pennsylvania Railroad bench mark)	828.737
Bessemer station, Pennsylvania Railroad, about 1 mile east of, east end of north abutment of double-track bridge of Union Railway over main line of Pennsylvania Railroad, in face of abutment; bronze tablet stamped "760 PITTSBURG 1899"	759.492
Thompson, 0.33 mile south of flag station, at south end of west abutment of Port Perry Railroad bridge across Monongahela River; copper bolt (Pennsylvania Railroad bench mark No. 13)	763.860
Thompson, 125 feet south of flag station, at signal tower, 25 feet west of south-bound track, 4 feet above top of rail, north wing wall of west abutment of double-track truss bridge of Union Railway crossing over tracks of Pennsylvania Railroad; bronze tablet stamped "767 PITTSBURG 1899"	766.881
Thompson, in front of flag station, south-bound track; top of west rail	762.9
Cochran (Duquesne post-office), in front of station, south-bound track; top of east rail	761.1
Dravosburg, in front of station, south-bound track; top of west rail	746.7
Camden, in front of station, north-bound track; top of east rail	753.7
Coal Valley, county bridge over creek; chiseled square on coping stone of wall (Pennsylvania Railroad bench mark No. 19, elevation 736.60)	736.303
Coal Valley, in front of station, south-bound track; top of west rail	754.2
Wilson, in front of station, south-bound track; top of west rail	756.5
Peters Creek, in front of flag station, south-bound track; top of east rail	752.5
Peters Creek, 0.25 mile south of flag station, 2-span stone arch culvert, first step below coping stone at southeast corner, 12 feet below top of rail; bronze tablet stamped "740 PITTSBURG 1899"	739.446
Blair, in front of flag station, north-bound track; top of east rail	757.6
Central Park, north-bound track at road crossing; top of west rail	754.9
East Elizabeth, in front of station, north-bound track; top of west rail	750.1
West Elizabeth, in front of station, north-bound track; top of east rail	746.4
Jones flag station, north-bound track; top of east rail	754.3
Walton flag station, south-bound track; top of east rail	756.4
Elben, in front of station, north-bound track; top of west rail	751.6

BROWNSVILLE QUADRANGLE.

ELBEN, ALONG PENNSYLVANIA RAILROAD, TO TIPPECANOE.

Shire Oaks, in front of station, north-bound track; top of west rail	750.1
Coal Bluff, in front of station, south-bound track; top of east rail	750.7
Huston Run, in front of station, north-bound track; top of west rail	754.8
Courtney, in front of station; top of east rail	759.1
Riverview; 0.3 mile north of flag station, south end of large stone-arch culvert, west side of track, second step below coping stone, 2.5 feet below top of rail; bronze tablet stamped "753 PITTSBURG 1899"	753.081
Riverview, in front of flag station; top of east rail	755.3
Monongahela City, in front of station; top of rail	753.8
Black Diamond flag station; top of west rail	753.9
Baird, 150 feet south of flag station, signpost, second step below coping stone of stone-arch culvert, north side of track, 4.8 feet below top of rail; bronze tablet stamped "755 PITTSBURG 1899"	754.954
Baird, in front of flag station; top of east rail	760.0
Webster, in front of station; top of west rail	761.1
West Columbia, in front of flag station; top of west rail	772.9
Bamford, in front of station; top of east rail	763.9
Lock No. 4, on coping near heel of west gate at south end of west lock, on circle; chisel mark	743.661
Lock No. 4; top of west rail	764.7
Charleroi, in front of station; top of west rail	764.0
Charleroi, 0.5 mile south of station, 150 feet south of city pumping station, coping stone at northwest corner of large stone-arch culvert; bronze tablet stamped "760 PITTSBURG 1899"	757.734
Belle Vernon, in front of station; top of east rail	767.2
Dunlevy, in front of flag station; top of west rail	763.4
Allenport, in front of station; top of west rail	764.5

	Feet.
Stockdale, in front of flag station; top of east rail	761.8
Lucyville, in front of station; top of west rail	766.7
Woods Run flag station, in front of; top of west rail	765.0
Woods Run flag station, 0.5 mile south of, bridge seat at east end of north abutment of open culvert, 25 feet south of milepost 47; bronze tablet stamped "764 PITTSBURG 1899"	765.241
Coal Center, in front of station; top of west rail	768.9
California, in front of station; top of east rail	766.4
West Brownsville Junction, in front of station; top of east rail	778.3
West Brownsville Junction, 0.25 mile south of, 4-span truss bridge across Monongahela River, bridge seat at east end of north abutment; bronze tablet stamped "778 PITTSBURG 1899".	777.579
Braznell, in front of flag station; top of east rail	798.8
Grindstone, in front of flag station; top of west rail	825.4
Tippecanoe, in front of flag station; top of west rail	859.4
Tippecanoe, 0.5 mile south of flag station, bridge seat at southwest corner of small girder bridge 15 feet long over roadway at south end of truss road bridge over Redstone Creek; bronze tablet stamped "868 PITTSBURG 1899"	867.466

MASONTOWN QUADRANGLE.

SMOCK, ALONG PENNSYLVANIA RAILROAD, TO WALTERSBURG.

Smock, in front of station; top of east rail	877.7
Rothbuck, in front of station; top of west rail	892.3
Waltersburg, in front of flag station; top of west rail	900.2

FAIRCHANCE, ALONG BALTIMORE AND OHIO RAILROAD, TO GANS.

Fairchance, 550 feet north of Baltimore and Ohio Railroad station, bridge seat at corner of small girder Bridge No. 338; aluminum tablet stamped "1065 PITTSBURG 1899"	1,065.184
Fairchance, in front of station; top of west rail	1,059.8
Smithfield, in front of station; top of west rail	985.5
Outcrop, in front of flag station; top of east rail	1,067.4
Outcrop, 0.2 mile south of flag station, northeast of Baltimore and Ohio tunnel, east of track, 3.7 feet above rail; bronze tablet stamped "1084 PITTSBURG 1899" [a]	1,083.840
Summit of grade; top of rail	1,089.5

UNIONTOWN QUADRANGLE.

WALTERSBURG, ALONG PENNSYLVANIA RAILROAD, TO UNIONTOWN.

Upper Middletown flag station, 675 feet north of, in face of rock in place, 26 feet east of center of track, 4.2 feet higher than top of rail; bronze tablet stamped "920 PITTSBURG 1899".	919.698
Upper Middletown flag station; top of rail	913.8
Vance Mill Junction, in front of station; top of east rail	927.0
Redstone Junction, in front of station; top of east rail	956.1
Uniontown, court-house, corner of Main and Court streets, foundation wall 4 feet above ground between Main street entrance and southwest corner and building; aluminum tablet stamped "999 PITTSBURG 1899"	908.833

UNIONTOWN, ALONG BALTIMORE AND OHIO RAILROAD, TO FAIRCHANCE.

Uniontown, in front of Pennsylvania Railroad station; top of east rail	980.7
Leith, in front of Pennsylvania Railroad station; top of west rail	1,005.9
Hutchinson, in front of flag station; top of east rail	1,106.1
Brownfield, in front of station; top of west rail	1,136.5
Oliphant, in front of flag station; top of west rail	1,170.6
Johnston, in front of flag station; top of west rail	1,098.6

MORGANTOWN QUADRANGLE.

GANS, ALONG BALTIMORE AND OHIO RAILROAD, TO THE STATE LINE.

Gans, in front of station; top of west rail	1,009.5
Atchison, in front of station; top of east rail	939.1
Cheat Haven, in front of station; top of west rail	835.4
Point Marion, 0.25 mile north of station, coping stone at east end of north pier of 6-span truss and girder Bridge No. 356 across Cheat River; bronze tablet stamped "813 PITTSBURG 1899"	812.892
Point Marion, in front of station; top of west rail	815.3
State line (W. Va.-Pa.); top of east rail	815.3

[a] Reported as having been disturbed by reconstruction of bridge; may be several feet lower than here given.

ERIE AND WARREN COUNTIES.

CORRY, UNION CITY, AND YOUNGSVILLE QUADRANGLES.

The elevations in the following list are the result of a line of precise levels run from Leboeuf to Irvineton. This line formed a factor in the 1903 adjustment of the precise-level net, the result of which was to lower the elevation by the unadjusted line 0.146 foot at Irvineton with respect to Leboeuf. This amount has therefore been distributed in this line proportional to the distance. The total divergence between the simultaneous, direct and reverse lines is 0.021 foot in a total distance of 38.7 miles.

The method of leveling and party outfit was similar to that previously used. The leveling was done in 1902 by Mr. D. H. Baldwin, topographer in charge. The standard bench marks are referred to an aluminum tablet at Pittsburg at the entrance to the Seventh Avenue Hotel, stamped "738 PITTSBURG 1899," the elevation of which is accepted as 738.383 feet above mean sea level. They are stamped with the legend "PITTSBURG 1902" in addition to the figures of elevation.

UNION CITY QUADRANGLE.

LEBOEUF, EAST ALONG ERIE RAILROAD TO UNION CITY, THENCE ALONG PITTSBURG AND ERIE RAILROAD TO ELGIN.

	Feet.
Leboeuf, 1.5 miles west of, north side of tracks, arch culvert, on coping stone; aluminum tablet stamped "1193 PITTSBURG 1899"	1 194.210
Leboeuf, 1 mile southwest of, near railroad crossing, southwest corner of highway bridge, on foundation stone; chiseled square	1,201.31
Union City, 1.69 miles west of, on Erie Railroad, on top of stone milepost 74; chiseled square.	1,259.60
Union City, 0.64 mile west of, Erie Railroad, on top of stone milepost 73; chiseled square....	1,284.37
Union City, in front of Erie station; top of north rail	1,299.9
Union City, 0.31 mile east of Erie station, top of stone milepost 72; chiseled square	1,302.92
Union City, 0.78 mile east of Pennsylvania Railroad station, Bridge No. 27, northeast corner, on parapet wall; chiseled square	1,289.13
Union City, 1.97 miles east of, northeast corner of Bridge No. 29, on foundation stone; chiseled square	1,302.06
Union City, 2.22 miles east of, east corner of Bridge No. 30, on foundation wall; copper bolt (Pennsylvania Railroad bench mark No. 72)	1,307.892
Reilly, flag road crossing; top of north rail	1,346.1
Elgin, 1.09 miles west of, northwest corner of Bridge No. 32, on parapet stone; chiseled square (Pennsylvania Railroad bench mark No. 71)	1,369.58
Elgin, 0.13 mile west of, northeast corner Bridge No. 33, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 70)	1,379.496
Elgin, 330 feet west of station, north of track, store of D. S. Lyon, southeast corner of foundation wall; aluminum tablet stamped "1382 PITTSBURG 1902"	1,381.794
Elgin, in front of station; top of north rail	1,386.4

CORRY QUADRANGLE.

LOVELL TO HORN.

Lovell, 0.84 mile west of, northeast corner of Bridge No. 34, on foundation wall; copper bolt (Pennsylvania Railroad bench mark No. 69)	1,366.676
Lovell, in front of station; top of north rail	1,374.2
Lovell, 0.16 mile east of, southwest corner of Bridge No. 37, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 68)	1,372.610
Corry, 2.68 miles west of, southeast corner of Bridge No. 38, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 67)	1,382.199
Corry, 1.13 miles west of, northwest corner of Bridge No. 40, bottom of coping stone of wing wall; copper bolt (Pennsylvania Railroad bench mark No. 66)	1,412.769
Corry, in front of station; top of north rail	1,429.1
Corry, 0.05 mile southwest of station, northeast corner of Phoenix Hotel, on base water table; aluminum tablet stamped "1432 PITTSBURG 1902"	1,432.341
Colza, 0.34 mile west of, southeast corner of Bridge No. 41, on top of foundation wall; copper bolt (Pennsylvania Railroad bench mark No. 64)	1,397.526
Colza, in front of station; top of north rail	1,400.7
Roach, in front of section house; top of north rail	1,381.2

	Feet.
Roach, 0.24 mile east of, southwest corner of Bridge No. 42 (large steel-truss bridge), on parapet wall; chiseled square (Pennsylvania Railroad bench mark No. 62)	1,384.170
Spring Creek, in front of station; top of north rail	1,395.5
Spring Creek, 100 feet northeast of station, southwest corner of Donaldson Brothers' general store, in water table; aluminum tablet stamped "1406 PITTSBURG 1902"	1,405.594
Spring Creek, 0.26 mile east of, south side of track, on coping stone at culvert; chiseled square (Pennsylvania Railroad bench mark No. 58)	1,390.04
Spring Creek, 0.70 mile east of, west side of open culvert, north side of track, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 57)	1,394.893
Spring Creek, 2.09 miles north of, northeast corner of girder Bridge No. 42¼, on wing wall; copper bolt (Pennsylvania Railroad bench mark No. 56)	1,375.846
Horn, 0.17 mile west of, southwest corner small girder bridge, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 55)	1,366.593
Horn, flag crossing; top of north rail	1,372.8

YOUNGSVILLE QUADRANGLE.

HORN TO IRVINETON.

Horn, 1.18 miles north of, south end of box culvert on coping stone; copper bolt (Pennsylvania Railroad bench mark No. 54)	1,322.334
Quarry, flag crossing; top of north rail	1,328.7
Garland, in front of station, main track; top of south rail	1,308.8
Garland, 1.12 miles east of, southwest corner of "Blue Eye" Bridge over Blue Eye Creek, on foundation stone; copper bolt (Pennsylvania Railroad bench mark No. 51)	1,285.041
Pittsfield, 1.83 miles west of, at southwest corner of bridge, on top of foundation wall; copper bolt (Pennsylvania Railroad bench mark No. 50)	1,264.709
Pittsfield, 0.52 mile west of, large steel through-truss bridge over creek, southeast corner of foundation stone; bronze tablet stamped "1244 PITTSBURG 1902"	1,244.249
Pittsfield, in front of station; top of north rail	1,240.6
Pittsfield, 0.13 mile east of, northwest corner of Bridge No. 46, on foundation wall; chiseled square (Pennsylvania Railroad bench mark No. 47)	1,237.68
Pittsfield, 0.75 mile east of, southwest corner of small bridge, on foundation wing wall; copper bolt (Pennsylvania Railroad bench mark No. 46)	1,231.197
Youngsville, 0.86 mile west of, southwest corner of Bridge No. 47, on foundation wall; copper bolt (Pennsylvania Railroad bench mark No. 45)	1,221.601
Youngsville, 0.32 mile west of, southwest corner of 6-span girder bridge over Brokenstraw Creek; copper bolt (Pennsylvania Railroad bench mark No. 48)	1,207.025
Youngsville, 0.15 mile west of, northeast corner of Dunkirk, Allegheny Valley and Pittsburg Railroad bridge, on projection of bottom foundation stone of pier; chiseled square (Pennsylvania Railroad bench mark No. 43)	1,211.305
Youngsville, in front of station; top of rail	1,210.8
Youngsville, in front of Dunkirk, Allegheny Valley and Pittsburg Railroad station; top of north rail	1,205.8
Irvineton, 0.70 mile west of, southwest corner of Bridge No. 49, on foundation wall; chiseled square (Pennsylvania Railroad bench mark No. 42)	1,173.032
Irvineton, in front of station; top of south rail	1,167.3
Irvineton, 0.24 mile east of station, east abutment of double-track steel-girder Bridge No. 50 across Brokenstraw Creek, north side of middle girder, on bridge seat; aluminum tablet stamped "1176 PITTSBURG 1899"	1,167.948

PRIMARY LEVELING.

TIOGA AND POTTER COUNTIES.

ELKLAND, GAINES, GALETON, AND TIOGA QUADRANGLES.

The following elevations are based upon bench marks at Corning and Addison, N. Y., on the precise-level line Dunkirk to Albany, N. Y. The reference bench mark is an aluminum tablet in the State library at Harrisburg stamped "364 HARRISBURG 1899," the elevation of which is accepted as 363.975 feet above mean sea level. The leveling was done in 1899 under the direction of Mr. J. H. Jennings, topographer, by Messrs. C. H. Semper and Robert Coe, levelmen. The standard bench marks are stamped "HARRISBURG" in addition to figures of elevation mostly 1 foot low.

ELKLAND QUADRANGLE.

ADDISON, N. Y., SOUTH ALONG BUFFALO AND SUSQUEHANNA RAILROAD TO ELKLAND, PA., THENCE WEST, VIA ACADEMY CORNERS, TO WESTFIELD.

	Feet.
Elkland, on west Main street, in front face of Pattison Bank; tablet stamped "1134 HARRISBURG 1899"	1,134.432
Academy Corners, in southeast corner of district schoolhouse; tablet stamped "1216 HARRISBURG 1899"	1,216.725
Knoxville, in about the middle of foundation of chimney on residence of H. I. Brewster, on south side of East Main street, being the third building from corner of Main and Water streets; aluminum tablet stamped "1239 HARRISBURG 1899"	1,240.368

ACADEMY CORNERS, SOUTH ALONG HIGHWAYS TO LITTLE MARSH, THENCE SOUTHEAST TO MIDDLEBURY CENTER.

Little Marsh, at east end of village, in top of third stone from east end of north abutment of iron highway bridge over Crooked Creek; bronze tablet stamped "1392 HARRISBURG 1899"	1,393.184
Middlebury Center, in top stone at south end of west pier of iron highway bridge over Crooked Creek; bronze tablet stamped "1149 HARRISBURG 1899"	1,150.004

GAINES, EAST ALONG BUFFALO AND SUSQUEHANNA RAILROAD AND NEW YORK CENTRAL RAILROAD TO STOKESDALE, THENCE NORTH ALONG LATTER TO MIDDLEBURY CENTER.

Ansonia, on north side of east abutment of highway bridge over Marsh Creek 200 feet west of Fall Brook Railway, in top of bridge seat stone; bronze tablet stamped "1136 HARRISBURG 1899"	1,136.884

STOKESDALE, SOUTH ALONG NEW YORK CENTRAL RAILROAD, TO WELLSBORO (SINGLE-SPUR LINE.)

Wellsboro, bronze tablets in stone monuments set in public square as meridian marks; stamped "1308 HARRISBURG 1899"—	
North monument (about 7 feet from Central avenue and 42 feet from Main street)	1,308.638
South monument (about 13 feet from Pearl street and 26 feet from Charles street)	1,309.305

TIOGA QUADRANGLE.

ELKLAND, EAST ALONG NEW YORK CENTRAL RAILROAD TO LAWRENCEVILLE, THENCE NORTH TO CORNING.

Nelson, in southeast corner of Nelson schoolhouse; tablet stamped "1077 HARRISBURG 1899"	1,077.978
Lawrenceville, at northwest corner of Main and Cowanesque streets, in top foundation stone on south side near southeast corner of building; aluminum tablet stamped "996 HARRISBURG 1899"	996.792

MIDDLEBURY CENTER, SOUTHEAST ALONG HIGHWAY TO EAST CHARLESTON, THENCE EAST TO MANSFIELD.

East Charleston, at northwest corner of brick residence of Seymour Whitney, in west face of foundation; aluminum tablet stamped "1656 HARRISBURG 1899"	1,656.891
Covington, in west face of foundation near northwest corner of I. O. O. F. hall, being third building south of State street, on east side of Williams street; bronze tablet stamped "1196 HARRISBURG 1899"	1,197.015
Mansfield, bronze tablets set in stone monuments on the grounds of the Mansfield State Normal School for meridian marks—	
North monument marked "1207 HARRISBURG 1899"	1,207.706
South monument marked "1196 HARRISBURG 1899"	1,196.804

MANSFIELD, NORTH ALONG ERIE RAILROAD, TO TIOGA.

Tioga, 2.5 miles south of; top of coping stone at west end of north abutment of steel-plate girder railroad bridge over Mill Creek	1,062.13
Tioga, in front face of buttress on south side of south entrance of St. Andrews Episcopal church; bronze tablet stamped "1036 HARRISBURG 1899"	1,037.041

SPUR LINE, SOUTHEAST ALONG MILL CREEK, TO PAINTER RUN.

	Feet.
Painter Run, in south face of foundation near southwest corner of Free Methodist Church, at forks of road where signboard reads "Summit 6 miles;" aluminum tablet stamped "1257 HARRISBURG 1899"	1,258.241

MIDDLEBURY CENTER, NORTHEAST ALONG NEW YORK CENTRAL AND HUDSON RIVER RAILROAD, TO TIOGA.

Crooked Creek, 1.25 miles north of, about 1,800 feet south of milepost 85–86, on west side of north abutment of small bridge; top of coping stone	1,103.80
Hammond, 0.75 mile north of, about 600 feet north of milepost 83–88, at west end of north abutment of small bridge; top of coping stone	1,075.52

TIOGA, NORTH ALONG ERIE RAILROAD, TO LAWRENCEVILLE.

Tioga, near Erie Railroad station, at north end of west abutment of highway bridge over Tioga River; top of coping stone	1,038.41
Lawrenceville, south end of east abutment of highway bridge over Tioga River, near railroad station; top of coping stone	993.43

TIOGA JUNCTION, EAST ALONG ERIE RAILROAD, TO JACKSON SUMMIT (SINGLE-SPUR LINE).

Jackson Summit, in north face of foundation near northeast corner of residence of O. B. Morrill, nearly opposite Erie station; bronze tablet stamped "1585 HARRISBURG 1899"	1,586.080

GAINES QUADRANGLE.

WESTFIELD, WEST ALONG NEW YORK CENTRAL RAILROAD, TO POINT 2.5 MILES WEST OF MILLS.

Westfield, at corner of Main and Church streets, in east face of top foundation stone at northeast corner of brick building; aluminum tablet stamped "1372 HARRISBURG 1899"	1,372.510
Harrison Valley, in south face of top foundation stone at the southeast corner of brick building owned by G. E. and D. T. Stone; bronze tablet stamped "1618 HARRISBURG 1899"	1,619.263
Mills, 2.5 miles west of, in top of cornerstone on north side of east abutment of bridge about 1,100 feet east of milepost 109–4; bronze tablet stamped "2022 HARRISBURG 1899"	2,022.877

WESTFIELD, SOUTH ALONG BUFFALO AND SUSQUEHANNA RAILROAD, TO GAINES, THENCE WEST TO WEST PIKE (SINGLE-SPUR LINE).

Sabinsville, at north end of village, in top of cornerstone on north side of east abutment of highway bridge over Mill Creek; bronze tablet stamped "1601 HARRISBURG 1899"	1,602.209
Gaines, at southeast corner of Hotel Vermilyea, in south face of foundation stone; bronze tablet stamped "1294 HARRISBURG 1899"	1,294.945
West Pike, in top of stone at north end of west abutment of steel railroad bridge over Genesee Fork of Pine Creek; a square hole	1,461.97

GAINES, NORTHWEST ALONG HIGHWAY TO SUNDERLINVILLE (SINGLE-SPUR LINE).

Sunderlinville, at the southwest corner of forks of road, northwest corner of building used as hotel, in west face of foundation stone; aluminum tablet stamped "1738 HARRISBURG 1899"	1,739.003

GALETON QUADRANGLE.

Galeton, in window sill on east end near southeast corner of building used as general office of Buffalo and Susquehanna Railroad; aluminum tablet stamped "1330 HARRISBURG 1899"	1,330.778

WARREN COUNTY.

SHEFFIELD AND WARREN QUADRANGLES.

The elevations in the following list are based upon the latest adjustment datum. For additional elevations on Warren quadrangle refer to "Precise leveling." The leveling was done in 1905 under the direction of Mr. Robert D. Cummin, topographer, by Mr. J. H. Wetzel, levelman. The standard bench marks are stamped "ADJ 1903" in addition to the figures of elevation.

WARREN QUADRANGLE.

WARREN, NORTH ALONG DUNKIRK, ALLEGHENY VALLEY AND PITTSBURG RAILROAD, TO FENTONVILLE, N. Y.

	Feet.
Warren, at street crossing, Dunkirk, Allegheny Valley and Pittsburg Railroad; top of rail	1,209.4
North Warren station, road crossing; top of rail	1,218.5
Warren Asylum, at north side of railroad entrance to powerhouse, west side of building, on window sill; bronze tablet stamped "1225 ADJ 1903"	1,224.538
Russell, near station, at northeast wing wall of covered highway bridge over Conewango Creek; bronze tablet stamped "1237 ADJ 1903"	1,237.460
Ackley, road crossing at station; top of rail	1,238.8
Ackley, 600 feet west of station, southeast bridge seat of highway and trolley bridge over Conewango Creek; bronze tablet stamped "1241 ADJ 1903"	1,240.743
Ackley, north end of siding at switch; top of rail	1,248.5

RUSSELL, EAST ALONG HIGHWAY, TO CORYDON.

Russell, 4 miles east of, southeast bridge seat of wooden bridge over Ackley Run; bronze tablet stamped "1519 ADJ 1903"	1,519.282
Russell, 6.5 miles east of, in southeast foundation stone of Hiram Lonsburry's residence; bronze tablet stamped "2097 ADJ 1903"	2,096.602

RUSSELL, NORTHWEST ALONG HIGHWAY TO MARSHS CORNERS, THENCE SOUTH TO PUTNAMVILLE, THENCE SOUTHEAST TO MOUTH OF RHIMES RUN.

Russell, 4 miles northwest of, at Marshs Corners, in northwest foundation stone of Herbert Philips's residence; bronze tablet stamped "1548 ADJ 1903"	1,547.612
Putnamville, 1,300 feet east of schoolhouse, in northwest foundation stone of Fletcher's frame residence; bronze tablet stamped "1663 ADJ 1903"	1,662.580

WARREN, SOUTHEAST ALONG PHILADELPHIA AND ERIE RAILROAD, TO TIONA AND RETURN.

Warren, 2 miles southeast of; railroad bench mark on rock	1,218.84
Stoneham; railroad bench mark No. 28 (description not given)	1,304.35
Stoneham, road crossing; top of rail	1,342.7
Stoneham station, 150 feet north of, at west entrance of stone building of Elk Tanning Company, in stone doorsill; bronze tablet stamped "1358 ADJ 1903"	1,357.971
Clarendon, railroad crossing; top of rail	1,391.5

SHEFFIELD QUADRANGLE.

AT TIONA.

Tiona, 600 feet north of station, in southeast bridge seat of iron bridge; aluminum tablet stamped "1358 ADJ 1903"	1,358.305

CRAWFORD AND ERIE COUNTIES.

ERIE, FAIRVIEW, AND GIRARD QUADRANGLES.

The elevations in the following list are based on an aluminum tablet stamped "635 ERIE" placed in the Soldiers' Home, at Erie, Pa., the elevation of which is now accepted as 636.179 feet above mean sea level. This is the initial bench mark for the precise-level line run south to Pittsburg, and was set by primary leveling from an army engineer's bench mark, consisting of a chisel mark in the southwest corner of the foundation of the light-house keeper's dwelling at Erie, the elevation of which is now accepted as 577.591. This work was previously reported upon in the Appendix to the Twenty-first Annual Report of the United States Geological Survey and is here corrected. For additional elevations on Erie quadrangle refer to list under "Precise leveling."

The leveling was done in 1899 under the general direction of Mr. Frank Sutton, topographer, by William Crennel, levelman. The bench marks dependent on this datum are stamped "ERIE" in addition to figures of elevation mostly 1 foot low.

ERIE QUADRANGLE.

GODARD, WEST ALONG HIGHWAY, TO FAIRVIEW, THENCE NORTHEAST, ALONG LAKE SHORE AND MICHIGAN SOUTHERN RAILWAY, TO ERIE.

	Feet.
Sterrettania, in southeast corner of foundation of Cook's flouring mill; aluminum tablet stamped "904 ERIE"	905.306
Erie, in water table northwest corner of hospital wing of Soldiers' Home; aluminum tablet stamped "635 ERIE"	636.179

FAIRVIEW QUADRANGLE.

FAIRVIEW, WEST ALONG LAKE SHORE AND MICHIGAN SOUTHERN RAILWAY, TO STATE LINE.

Fairview, in southwest corner of foundation of store owned by David Yeagle; aluminum tablet stamped "795 ERIE"	796.283

GIRARD QUADRANGLE.

Girard Junction, 6.5 miles west of, southeast corner of coping of west abutment of culvert under Lake Shore and Michigan Southern Railway, at crossing; bench mark, stamped "Br # 8"	649.72
State line (Pa.–Ohio), on south side of pedestal of monument, 1.25 miles north of Lake Shore and Michigan Southern Railway; aluminum tablet stamped "635 ERIE"	635 595

STATE LINE, SOUTH-SOUTHEAST OVER HIGHWAY, VIA TRACY, TO CONNEAUTVILLE. THENCE NORTHEAST TO HICKERNELL, THENCE NORTH TO GIRARD.

West Springfield, in foundation west side of A. J. Thomas's barn; aluminum tablet stamped "712 ERIE"	712.772
Tracy, 1 mile south of and just south of creek bridge, in northwest corner of foundation of house owned by Mr. Culberson; aluminum tablet stamped "952 ERIE"	953.120
Beaver Center, store owned by L. L. Fuller, in northeast corner of foundation; aluminum tablet stamped "1029 ERIE"	1,030.316
Conneautville, in southeast corner of foundation of bank building; aluminum tablet stamped "948 ERIE"	949.142
Hickernells, on northeast corner of foundation of post-office; bronze tablet stamped "1127 ERIE"	1,128.134
Pont, in front foundation of United Brethren Church; bronze tablet stamped "1090 ERIE"	1,090.699
Platea, in southwest corner of foundation of Methodist Church; bronze tablet stamped "876 ERIE"	876.400
Girard, Dobler's farm; northwest corner of stone flag foundation of fountain and watering trough	799.22

BERKS, CHESTER, DELAWARE, AND LANCASTER COUNTIES.

COATESVILLE, PHOENIXVILLE, SUPLEE, AND WEST CHESTER QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the State Library at Harrisburg, stamped "364 HARRISBURG 1899." The initial points are various bench marks along precise-level lines of the Pennsylvania Railroad, the heights accepted for which accord with the 1903 adjustment.

The leveling on the West Chester quadrangle was done in 1900 under the direction of Mr. Hersey Munroe, topographer, by Mr. Hargraves Wood, levelman, and that on the other quadrangles was done in 1903 under the direction of Mr. F. Sutton, topographer, by Mr. J. H. Wetzel, levelman. Standard bench marks are stamped "HARRISBURG" in addition to the figures of elevation.

WEST CHESTER QUADRANGLE.

WEST CHESTER TO WESTTOWN.

	Feet.
West Chester, near northwest corner of county court-house grounds, Market and North High streets, in top of wall; aluminum tablet stamped "HARRISBURG 459"	458.935
Westtown, 500 feet west of station, at west end and north side of bridge over Chester Creek, in top of approach to wall; bronze tablet stamped "263 HARRISBURG"	263.288

WESTTOWN, VIA THORNBURY AND DILWORTHTOWN, TO BRANDYWINE SUMMIT.

	Feet.
Brandywine Summit, at northeast corner of crossroads, D. B. Martin's residence, in south face of west stone gatepost; bronze tablet stamped "427 HARRISBURG 1900"	427.114

SPUR LINE, WEST FROM BRANDYWINE SUMMIT TO CHADS FORD STATION.

Chads Ford, 200 yards east of station, on west abutment of railroad bridge, south side; bronze tablet stamped "168 HARRISBURG 1900"	168.417
Elam (discontinued post-office), 1.25 miles south of, 120 feet west of Wilmington pike, in top of State line stone No. 16; aluminum tablet stamped "384 HARRISBURG 1900"	384.174

STATE CORNER NO. 6, VIA KENNETT SQUARE, WILLOWDALE, UNIONVILLE, GLENHALL, AND MARSHALLTON, TO WEST CHESTER.

Willowdale, 350 feet south of post-office, east side of road to Kennett Square, at northeast end of stone chapel, on stone doorsill; bronze tablet stamped "387 HARRISBURG 1900"	387.712
Glenhall, Pennsylvania Railroad crossing at station; top of rail	210.8
Glenhall, 565 feet north of, 245 feet north of north end of highway bridge over Brandywine Creek, east side of road near spring, in ledge of rock; bronze tablet stamped "216 HARRISBURG 1900"	216.397

COATESVILLE QUADRANGLE.

COATESVILLE, SOUTHEAST ALONG PHILADELPHIA AND READING RAILROAD, TO GLENHALL.

Coatesville, Pennsylvania Railroad station, in doorsill; copper bolt	381.25
Coatesville, road crossing; top of rail	305.29
Mortonville, 2,700 feet south of, southeast abutment of railroad bridge; bronze tablet stamped "245 HBG"	245.264
Laurel, in front of station; top of rail	241.3

KENNETT SQUARE, WEST ALONG PHILADELPHIA, WILMINGTON AND BALTIMORE RAILROAD, TO OXFORD, THENCE NORTH, ALONG HIGHWAY, TO PARKSBURG.

Avondale, 450 feet east of station, railroad Bridge No. 33, on northeast bridge seat; bronze tablet stamped "272 HARRISBURG 1903"	272.254
Avondale station, road crossing; top of rail	277.3
West Grove, 200 feet south of station, road crossing; top of rail	390.3
West Grove, 1.2 miles south of, on northeast abutment of overhead bridge; copper bolt	450.475
Kelton station, road crossing; top of rail	545.9
Kelton, 600 feet south of, on east side of track, on stone pier of overhead wagon bridge; bronze tablet stamped "554 HARRISBURG 1903"	554.228
Lincoln University, 100 feet south of station, at road crossing; stone marker	487.0
Oxford, 2 miles north of, Bridge No. 47, over Elk Creek, on northwest wing wall; copper bolt.	405.954
Oxford, 1,200 feet east of station, north side of track, on small culvert; bronze tablet stamped "507 HARRISBURG"	506.704
Russellville, 1.2 miles north of, at northeast corner stone of porch of S. P. Martin; bronze tablet stamped "631 HARRISBURG"	630.870
Parksburg, Pennsylvania Railroad passenger station, doorsill; copper bolt	540.90
Parksburg, 1,200 feet west of Pennsylvania Railroad station, culvert under street railroad, Bridge No. 62, northeast abutment; aluminum tablet stamped "542 HARRISBURG 1903".	543.631

COATESVILLE, NORTH ALONG PHILADELPHIA AND READING RAILROAD, TO BIRDSBORO.

Coatesville, 200 feet north of stone-arch railroad bridge, southeast end of east abutment of railroad bridge over Brandywine Creek; aluminum tablet stamped "314 HBG"	314.580
Valley station, road crossing; top of rail	340.2
Valley, small bridge 0.6 mile north of station, west end of north abutment	376.05

SUPLEE QUADRANGLE.

PARKSBURG, NORTH ALONG HIGHWAY, VIA COMPASS, TO BEARTOWN.

Compass, at entrance to P. E. Church, in stone doorsill; aluminum tablet stamped "520 HARRISBURG 1903"	519.835
Churchtown road, 0.3 mile west of station, northwest abutment of the Downingtown and Lancaster Railroad Bridge No. 17 over pike; top of coping stone	856.25
Wagontown; top of rail	464.8
Cedar Knoll, in front of station; top of rail	549.0

	Feet.
Cedar Knoll, 0.8 mile north of, railroad bridge over Brandywine Creek, east end of south abutment; bronze tablet stamped "548 HBG"	548.020
Brandamore, road crossing; top of rail	571.3
Ferndale station; top of rail	593.3
Birdell, road crossing; top of rail	601.4
Suplee, 250 feet north of station, road crossing; top of rail	645.2
Suplee, 2,400 feet north of, overhead highway bridge, 15 feet from south end of west pier, on top stone; bronze tablet stamped "644 HARRISBURG 1903"	644.564
Fountain station, road crossing; top of rail	647.2
Isabella, road crossing; top of rail	645.4
Conestoga, road crossing; top of rail	645.5
Elverson station, road crossing; top of rail	645.5
Elverson, southeast corner of wareroom of cannery, on top stone in foundation; aluminum tablet stamped "634 HARRISBURG"	634.593
Kenny station, road crossing; top of rail	627.1
Joanna station, road crossing; top of rail	625.8
Joanna Heights, road crossing; top of rail	600.5
Cold Run station, road crossing; top of rail	512.9
Geigertown, road crossing at station; top of rail	425.0
White Bear station, road crossing; top of rail	349.6
White Bear, 100 feet north of station, railroad bridge over Hay Creek, on southeast wing wall; aluminum tablet stamped "345 HARRISBURG"	345.434
Trap Rock station, in front of, top of rail	256.78
South Birdsboro station, road crossing; top of rail	215.1

SUPLEE, WEST ALONG DOWNINGTOWN AND LANCASTER RAILROAD, TO BEARTOWN.

Buchanans Road station, road crossing; top of rail	671.3
Honey Brook station, 200 feet west of, road crossing, top of rail	739.9
Honey Brook, 1.4 miles west of, Bridge No. 16, northeast bridge seat	817.79
Churchtown, road crossing, top of rail	876.0

SPUR TO BEARTOWN.

Beartown, in east pier of platform of railroad station; aluminum tablet stamped "773 HARRISBURG 1903"	773.654
Beartown, road crossing, top of rail	771.6

WHITE BEAR (SCARLETS MILL POST-OFFICE), WEST ALONG HIGHWAY, TO HUMMEL'S STORE

White Bear, 100 feet north of station, southeast wing wall of railroad bridge over Hay Creek; aluminum tablet stamped "345 HARRISBURG"	345.434
Plowville, 2 miles west of, 0.25 mile east of Hummel's store, large stone step at entrance to schoolhouse, bronze tablet stamped "730 HARRISBURG	730.492

PHOENIXVILLE QUADRANGLE.

GLEN LOCH TO WEST CHESTER.

Glen Loch, 0.2 mile east of, Pennsylvania Railroad Bench Mark No. 27, in south parapet of King Road Bridge; copper bolt	459.09

DOWNINGTOWN, NORTH ALONG HIGHWAY, VIA MILFORD MILLS AND PUGHTOWN, TO POTTSTOWN

Downingtown, Viaduct avenue arch, north end, copper bolt	255.223
Downingtown, west side of north end of Viaduct avenue arch, 720 feet east of station; bronze tablet stamped "255 HARRISBURG"	255.233
East Downingtown station, road crossing; top of rail	242.36
Dowlin station, road crossing; top of rail	274.5
Dorlan station, road crossing; top of rail	288.4
Dorlan, 0.1 mile north of, Bridge No. 6; southeast bridge seat	289.44
Milford Mills, covered wagon bridge over Marsh Creek, near blacksmith shop; east end stone of northeast wing wall	315.79
Pughtown, south end of, at entrance to schoolhouse, on stone step; bronze tablet stamped "273 HARRISBURG 1903"	273.535
Pottstown, passenger station; copper bolt on doorsill	138.76

	Feet.
Pottstown, 150 feet west of station, stone-arch bridge of Pennsylvania Railroad, in southeast corner of coping stone; bronze tablet stamped "136 HARRISBURG 1903"	135.968
Spring City, west of, canal bridge, east bridge seat; copper bolt	114.26
Spring City, 1 mile west of, 480 feet west of Pennsylvania Railroad bridge over canal, in southeast bridge seat of undergrade wagon bridge; bronze tablet stamped "117 HARRISBURG 1903"	117.651

AT PHOENIXVILLE.

Gay Street Bridge, south of track, capstone of pier of east column; square	128.657
Phoenixville, 900 feet east of passenger-station, northeast coping stone of bridge over Main street; aluminum tablet stamped "127 HARRISBURG 1903"	127.330

AT FRAZER.

North end of undergrade bridge, east bridge seat; copper bolt	487.588
Frazer, at station, north end of undergrade railroad bridge, west bridge seat; aluminum tablet stamped "487 HARRISBURG 1903"	487.397

BERKS, LANCASTER, LEBANON, AND LEHIGH COUNTIES.

LANCASTER, SLATINGTON, AND WERNERSVILLE QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the State Library at Harrisburg stamped "364 HARRISBURG 1899." The initial points are various bench marks of the transcontinental line of the United States Coast and Geodetic Survey and of the Pennsylvania Railroad, the accepted heights for which accord with the 1903 adjustment.

The leveling on the Slatington and Wernerville quadrangles was previously reported upon in Bulletin No. 185, and was done in 1900 under the direction of Mr. Hersey Munroe, topographer, by Messrs. B. E. White and Hargraves Wood, levelmen, and that on the Lancaster quadrangle was mostly done in 1901–2 under the direction of Mr. J. H. Wheat, topographer, by Mr. J. S. B. Daingerfield, levelman. The line, Clay to Brickerville, was run in 1905 under Mr. Robert D. Cummin, topograher, by Mr. J. H. Wetzel, levelman. The standard bench marks are stamped with the letters "HARRISBURG" or "HGB" in addition to the figures of elevation.

LANCASTER QUADRANGLE.

LANCASTER, NORTH ALONG PUBLIC ROADS, VIA LITITZ AND BRUNERVILLE, TO BRICKERVILLE.

	Feet.
Lancaster, on northeast corner of foundation wall of court-house, corner North Duke street and alley; aluminum tablet stamped "369 HARRISBURG"	368.904
Lancaster, on west doorsill of Pennsylvania Railroad station; copper bolt (Pennsylvania Railroad bench mark No. 81)	359.714
Lititz, west side of fountain, on wall; aluminum tablet stamped "385 H G B"	385.403
Brickerville, northeast corner foundation of hotel; aluminum tablet stamped "538 H G B"	538.974

BRICKERVILLE, WEST ALONG PUBLIC ROADS, TO MOUNT HOPE, THENCE SOUTH ALONG PUBLIC ROADS, VIA OLD LINE, SALUNGA, AND SILVER SPRING, TO MOUNTVILLE.

Old Line 1.3 miles north of, at intersection of roads, set in rock; iron post stamped "U. S. 596" (Not U. S. Geol. Survey)	596.148
Old Line (discontinued post-office), 650 feet northwest of, southeast corner of foundation of large barn; aluminum tablet stamped "584 H G B"	583.871
Salunga, overhead bridge, south pier, east end; aluminum tablet stamped "405 H G B"	404.716
Salunga, overhead bridge, south pier, west end; copper bolt (Pennsylvania Railroad bench mark No. 88)	404.779
Mountville, 0.4 mile west of, south parapet of culvert; copper bolt (Pennsylvania Railroad bench mark No. 123)	390.709
Mountville, west of, on south parapet of culvert; bronze tablet stamped "391 H G B"	390.705

CLAY TO BRICKERVILLE.

	Feet.
Clay, Grant Steinmetz Hotel, in southeast corner stone; bronze tablet stamped "363 ADJ 1903".	362.560

SLATINGTON QUADRANGLE.

MACUNGIE, NORTHWEST ALONG HIGHWAY, VIA FOGELSVILLE, TO LYON VALLEY.

Macungie station, 0.5 mile west of; square cut on top of stone of the middle of the south side of Philadelphia and Reading Railroad bridge over small run, marked "XXII B. M. 1881" U. S. C. G. S. B. M.	383.822
Fogelsville, German Reformed Church; aluminum tablet set in southwest corner of foundation wall under corner stone, stamped "514 HARRISBURG 1900"	514.369
Claussville, on south end of doorstep of schoolhouse; chiseled square	684.05

LYON VALLEY, NORTHWEST ALONG HIGHWAY, TO NEW TRIPOLI, THENCE NORTHEAST ALONG PHILADELPHIA AND READING RAILROAD, TO SLATINGTON.

New Tripoli, 0.5 mile northeast of; bronze tablet set in in southeast corner of stone basement of barn owned by A. Bennikoff, stamped "573 HARRISBURG 1900"	572.822
Germansville depot; top of rail at road crossing, marked "608" on plank	607.7
Germansville, 600 feet north of crossing by station, on north end of bridge seat, east abutment of railroad trestle bridge over Jordan Creek; chiseled square	601.07
Best, 500 feet northeast of railroad station; bronze tablet set in north end of bridge seat, west abutment of small railroad bridge, stamped "548 HARRISBURG 1900"	548.318

SLATINGTON, SOUTHEAST ALONG LEHIGH VALLEY RAILROAD TO ROCKDALE, THENCE SOUTHWEST ALONG HIGHWAY TO LYON VALLEY.

Slatington, 0.8 mile south of; iron bolt in west pier of Lehigh and New England Railroad, overhead crossing bridge over Lehigh Valley Railroad, marked "U. S. G. S. B. M. 358" (Lehigh Valley Railroad bench mark No. 92)	357.83
Rockdale, 250 feet north of station, at southeast corner of water tank of Lehigh Valley Railroad, in foundation stone under pillar; bronze tablet stamped "354 HARRISBURG 1900"	353.785
Unionville (Neffs post-office), Union Church; east end of lower stone step of front entrance	687.14

WERNERSVILLE QUADRANGLE.

WOMELSDORF, VIA HOST POST-OFFICE, SCHAEFFERSTOWN (TULPEHOCKEN POST-OFFICE), BERNVILLE, GARFIELD, AND BROWNSVILLE, TO WERNERSVILLE.

Womelsdorf, 1.5 miles west of, at Philadelphia and Reading Railroad overhead bridge, at north wall, east side; cut in base (United States Coast and Geodetic Survey bench mark)	483.488
Womelsdorf, at northwest corner of Main and Second streets, in east side of foundation, south end of Filbert & Bros. store; aluminum tablet stamped "433 HARRISBURG"	433.582
Host post-office, west side of Jacob Shaffner & Co.'s store, in top wall; bronze tablet stamped "369 HARRISBURG"	368.806
Schaefferstown (Tulpehocken post-office), St. Paul's Church, in west side of stone doorsill; bronze tablet stamped "491 HARRISBURG"	491.427
Garfield post-office, in northeast corner of stone house belonging to postmaster; bronze tablet stamped "367 HARRISBURG"	367.316
Brownsville (Lower Heidelberg post-office), in the east side of south front of schoolhouse; bronze tablet stamped "380 HARRISBURG"	379.612

WERNERSVILLE, WEST ALONG PHILADELPHIA AND READING RAILROAD AND HIGHWAY, VIA ROBSONIA FURNACE, TO COUNTY LINE.

Wernersville, 800 feet west of station, ledge of rock on north side of Philadelphia and Reading Railroad under highway bridge at base of north abutment; bronze tablet stamped "388 HARRISBURG"	387.636
South Mountain, in front of station; top of rail	394.78
Robsonia station, 0.1 mile east of, Philadelphia and Reading Railroad bridge over creek, north side, middle pier; United States Coast Survey bench mark No. XXIV	432.824
Berks-Lancaster County line, about 0.9 mile south of and 0.1 mile south of house at road forks, in large bowlder; bronze tablet stamped "983 HARRISBURG"	982.782

LANCASTER COUNTY.

NEW HOLLAND QUADRANGLE.

The elevations in the following list are based upon the Pennsylvania Railroad elevations, corrected to accord with the latest adjustment of precise leveling. The leveling was done in 1905 under the direction of Mr. Robert D. Cummin, topographer, by Mr. J. H. Wetzel, levelman. The standard bench marks are stamped "ADJ 1903" in addition to the figures of elevation.

NEW HOLLAND QUADRANGLE.

GAP, NORTH ALONG HIGHWAY, TO REAMSTOWN, THENCE WEST TO CLAY.

	Feet.
Gap, in doorsill of passenger station; copper bolt	549.360
Gap, 3 miles northwest of; in fifth stone step to entrance to Hess's mill near Pequea Creek; bronze tablet stamped "384 ADJ 1903"	383.560
New Holland, 3 miles south of, in brick store building of John Ellsworth, to left of entrance; aluminum tablet stamped "473 ADJ 1903"	473.289
New Holland, opposite side of street from station, in south side of D. M. Rutter & Co.'s grain warehouse, in stone doorsill; bronze tablet stamped "493 ADJ 1903"	493.106
New Holland, at Styre House, at street crossing; top of rail	521.9
Hinkletown, near mill and hotel, on coping stone of north end of west pier of iron highway bridge over Conestoga Creek at west end of town; aluminum tablet stamped "331 ADJ 1903".	330.941
Reamstown, in upper stone steps at entrance to Reamstown Hotel; bronze tablet stamped "391 ADJ 1903"	391.354
Stevens, 0.3 mile west of, in southeast foundation of Adam Sleighbaugh's barn; bronze tablet stamped "393 ADJ 1903"	393.391
Stevens, 2.5 miles west of, near Mermonite Church, in northeast foundation stone of Abraham Eberly's stone barn; bronze tablet stamped "419 ADJ 1903"	418.515

WITMER, NORTH ALONG HIGHWAY, VIA OREGON, TO CLAY.

Witmer, 0.5 mile west of; copper bolt on overhead bridge	381.78
Harman, railroad crossing; top of rail	391.9
Leacock post-office, 1 mile west of, southwest wing wall of double stone-arch bridge over small stream in top coping stone; bronze tablet stamped "315 ADJ 1903"	315.306
Oregon, southeast corner of H. Hosteder's stone mill; bronze tablet stamped "297 ADJ 1903".	297.076
Brownstown, 0.5 mile north of, in southeast corner foundation of Blackbill's Hotel; bronze tablet stamped "360 ADJ 1903"	360.354
Millway, in west doorsill at entrance to F. S. Bruboker's stone mill; bronze tablet stamped "316 ADJ 1903"	316.084
Millway, 2.5 miles north of, in limestone at southeast corner of J. F. Zell's garden, along side of road at intersection of roads; bronze tablet stamped "323 ADJ 1903"	323.090

CUMBERLAND AND YORK COUNTIES.

NEW CUMBERLAND QUADRANGLE.

The elevations in the following list are based upon the Pennsylvania Railroad elevations, corrected to accord with the latest adjustment of precise leveling. The leveling was done in 1905 under the direction of Mr. Robert D. Cummin, topographer, by Mr. J. H. Wetzel, levelman. The standard bench marks are stamped "ADJ 1903" in addition to the figures of elevation.

NEW CUMBERLAND QUADRANGLE.

MECHANICSBURG, SOUTH ALONG HIGHWAY, VIA SHEPARDSTOWN, TO MOUNT TOP, THENCE SOUTHEAST TO DOVER, THENCE NORTHEAST TO ZION VIEW, THENCE NORTH TO CLY.

	Feet.
Shepherdstown, on southeast corner of brick schoolhouse; aluminum tablet stamped "633 ADJ 1903"	633.061
Bowmansdale, 5 miles south of, in north end wall of porch at entrance of W. H. Lerew's store; aluminum tablet stamped "720 ADJ 1903"	720.230
Mount Top post-office on southeast corner of store of W. E. Wiley; bronze tablet stamped "594 ADJ 1903"	594.052

	Feet.
Wellsville, 1 mile west of, southwest wing wall of highway bridge over Doe Run; bronze tablet stamped "460 ADJ 1903"	460.179
Roler, on southeast corner of Emig's mill; aluminum tablet stamped "364 ADJ 1903"	364.336
Dover, Peter Brunhous's hotel, in stone pier to porch at ladies entrance; primary traverse station No. 8, stamped "453 ADJ 1903"	453.060
Zion View, southeast entrance to Zion Church; aluminum tablet stamped "378 ADJ 1903"	377.957
Strinestown, at northwest corner of schoolhouse; bronze tablet stamped "450 ADJ 1903"	449.487
Cly, east side of an arch 675 feet north of milepost 70; copper bolt Northern Central Railroad bench mark No. 74	302.84

JUNIATA AND PERRY COUNTIES.

MILLERSTOWN AND NEW BLOOMFIELD QUADRANGLES.

The elevations in the following list are based upon various bench marks of the Pennsylvania Railroad within this area. They accord with the 1903 adjustment of the railroad levels. The leveling was done in 1904, under the direction of Mr. R. D. Cummin, topographer, by Mr. Ira M. Flocker, levelman. The standard bench marks are stamped with the legend "ADJ 1903," in addition to the figures of elevation.

NEW BLOOMFIELD QUADRANGLE.

COVE FORGE STATION, SOUTHWEST ALONG HIGHWAY TO KEYSTONE, THENCE WEST VIA SHERMANSDALE TO FALLING SPRINGS, THENCE NORTH TO NEW BLOOMFIELD.

	Feet.
Cove Creek arch; copper bolt Pennsylvania Railroad bench mark No. 12	351.715
Keystone post-office, 0.5 mile west of, Rye Township, schoolhouse District No. 2, in foundation; bronze tablet stamped "598 ADJ 1903"	597.593
Shermans Dale, 150 feet west of Union Hotel, opposite south end of covered bridge, in corner stone of old wall; aluminum tablet stamped "445 ADJ 1903"	445.281
Falling Springs, 0.5 mile east of, in northwest corner of stone mill of M. L. Rice; aluminum tablet stamped "471 ADJ 1903"	471.432

DUNCANNON, WEST ALONG PERRY COUNTY RAILROAD, VIA NEW BLOOMFIELD, TO MANNSVILLE JUNCTION, THENCE NORTH ALONG HIGHWAY TO MARKETSVILLE, THENCE EAST TO NEWPORT.

Duncannon, railroad bridge over Sherman Creek, in bridge seat of northeast wing wall; aluminum tablet stamped "349 ADJ 1903"	349.066
Duncannon, northeast wing wall of bridge over Sherman Creek; Pennsylvania Railroad bench mark	355.400
Sulphur Springs, 600 feet west of, in southwest corner of abutment of railroad bridge; bronze tablet stamped "416 ADJ 1903"	415.762
Hoffman station, 700 feet west of, 300 feet south of track, in northeast corner of foundation of barn; aluminum tablet stamped "568 ADJ 1903"	568.546
New Bloomfield, on west side of main entrance of court-house, in top stone of foundation; bronze tablet stamped "679 ADJ 1903"	678.840
Valley station, bridge of Newport and Sherman Valley Railroad, in southwest bridge seat; bronze tablet stamped "717 ADJ 1903"	717.360
Sylvan station, 0.25 mile north of, 300 feet south of road forks, wooden bridge over Little Buffalo Creek, northwest corner of north abutment; bronze tablet stamped "543 ADJ 1903"	543.300
Marketville, covered bridge over Big Buffalo Creek, in northwest corner of north abutment; bronze tablet stamped "494 ADJ 1903"	494.363
Juniata post-office, near village of Milford, 80 feet east of covered bridge over Big Buffalo Creek, top of wing wall of small bridge; bronze tablet stamped "441 ADJ 1903"	440.640
Newport, square cut on tank house (Pennsylvania Railroad bench mark)	396.296
Newport, Little Buffalo Creek Bridge, northeast wing wall; copper bolt (Pennsylvania Railroad bench mark)	394.179
Newport, in southeast wing wall of Little Buffalo Creek Pennsylvania Railroad bridge; bronze tablet stamped "394 ADJ 1903"	394.187

MILLERSTOWN QUADRANGLE.

THOMPSONTOWN, NORTH ALONG HIGHWAY, TO EAST SALEM. (TWO DIRECT LINES.)

	Feet.
Thompsontown, north abutment of overhead bridge; Pennsylvania Railroad bench mark...	420.188
Thompsontown, Emmanuel Lutheran Church, in stone step; bronze tablet stamped "465 ADJ 1903"	464.810
East Salem, top of stone step of schoolhouse; bronze tablet stamped "620 ADJ 1903"	620.020

MILLERSTOWN, NORTHEAST ALONG HIGHWAY TO PFOUTS VALLEY, THENCE SOUTH TO BERLEE, THENCE SOUTHWEST TO POINT OPPOSITE OLD FERRY STATION, THENCE NORTHWEST TO MILLERSTOWN.

Millerstown, overhead bridge, Pennsylvania Railroad bench mark	409.267
Millerstown, in foundation of the Ward House; bronze tablet stamped "432 ADJ 1903"	432.302
Pfouts Valley, in east foundation of post-office; bronze tablet stamped "694 ADJ 1903"	694.327
Berlee (discontinued post-office), 800 feet northeast of, in east side of foundation of schoolhouse; bronze tablet stamped "504 ADJ 1903"	503.840
Old Ferry station, opposite, in southwest corner of foundation of barn; bronze tablet stamped "428 ADJ 1903"	427.957

MILLERSTOWN, NORTH ALONG HIGHWAY, TO EVENDALE, THENCE EAST TO ORIENTAL, THENCE SOUTH TO PFOUTS VALLEY.

Evendale post-office, brick house of J. H. Yodira, in northeast corner of foundation; bronze tablet stamped "714 ADJ 1903"	714.561
Richfield, northwest corner of Richfield Lutheran Church, in foundation stone; bronze tablet stamped "658 ADJ 1903"	658.012
Oriental post-office, 4 miles west of, 4 miles east of Richfield, in abutment of bridge over Mahantango Creek; bronze tablet stamped "553 ADJ 1903"	553.062
Oriental post-office, 300 feet west of, in wing wall of wood and iron bridge; bronze tablet stamped "468 ADJ 1903"	467.926

EVENDALE, SOUTHWEST ALONG HIGHWAY, TO BROWN'S MILL (COCOLAMUS POST-OFFICE) AND RETURN.

Cocolamus post-office (Brown's mill), just below, in wing wall of iron bridge over Cocolamus Creek; bronze tablet stamped "636 ADJ 1903"	636.144

CUMBERLAND, FRANKLIN, AND YORK COUNTIES.

CARLISLE, CHAMBERSBURG, HANCOCK, AND MERCERSBURG QUADRANGLES.

The elevations in the following list are based upon various bench marks of the transcontinental precise-level line of the United States Coast and Geodetic Survey and accord with the latest adjustment. They are referred to an aluminum tablet in the State Library at Harrisburg, stamped "364 HARRISBURG 1899," the elevation of which is now accepted as 363.975 feet above mean sea level. The work was previously reported upon in Bulletin No. 185.

The leveling was done in 1900, under the direction of Mr. R. D. Cummin, topographer, by Mr. F. M. Taylor, levelman. The standard bench marks are stamped with the letters "HARRISBURG," in addition to the figures of elevation. The bench mark near Sylvan was set by a double-targeted line from Cherry Run, W. Va., and is stamped "C," referring to Cumberland datum.

CARLISLE QUADRANGLE.

CARLISLE, VIA MOUNT HOLLY, TO IDAVILLE.

	Feet.
Mount Holly Springs, in southwest corner of Philadelphia and Reading station; bronze tablet stamped "556 HARRISBURG 1900"	555.640

IDAVILLE, VIA YORK SPRINGS AND DILLSBURG, TO MECHANICSBURG.

	Feet.
Idaville, in east side of P. L. Houck's house; bronze tablet stamped "805 HARRISBURG 1900"	805.175
York Springs in southwest corner of brick hall; bronze tablet stamped "607 HARRISBURG 1900"	606.673
Dillsburg, in southwest corner of brick schoolhouse; bronze tablet stamped "613 HARRISBURG 1900"	613.271
Mechanicsburg, west side of brick high school, at right front entrance; bronze tablet stamped "456 HARRISBURG 1900"	455.929

MECHANICSBURG TO CARLISLE.

New Kingston, curbstone in front of Doctor Faulk's house; chiseled cross	453.55

MOUNT HOLLY TO WILLIAMS GROVE.

Leidighs station, 0.33 mile east of, right side of track, capstone of abutment of bridge; chiseled mark	451.91

CHAMBERSBURG QUADRANGLE.

CHAMBERSBURG TO FAYETTEVILLE.

Fayetteville, in foundation stone east side of Union brick church; bronze tablet stamped "792 HARRISBURG 1900"	791.90

CHAMBERSBURG, VIA SCOTLAND AND GREENVILLE, TO WEST FAYETTEVILLE.

Scotland, southeast wing wall of bridge over Conococheague Creek, between Soldiers' Orphans Industrial School and Scotland station; capstone, chiseled cross	670.88
Green Village, in southeast cornerstone of brick schoolhouse; bronze tablet stamped "678 HARRISBURG 1900"	678.157

GREENCASTLE, VIA MARION JUNCTION, TO MERCERSBURG JUNCTION.

Marion Junction, 1 mile west of, Cumberland Valley Railroad, southwest of milepost 60; top of iron support of standard	578.24

GREENCASTLE, TO WAYNESBORO.

Zullinger, stone horse block in front of Louis Hovis's house; chiseled cross	748.55

FAYETTEVILLE TO WAYNESBORO.

Mount Alto (Funkstown or Altondale), entrance to M. E. Church, in left side of stone step; aluminum tablet stamped "848 HARRISBURG 1900"	847.625
Waynesboro, in stone in north foundation of Western Maryland Railroad station: aluminum tablet stamped "712 HARRISBURG 1900"	712.061

HANCOCK QUADRANGLE.

CHERRY RUN, W. VA., NORTH ALONG HIGHWAYS THROUGH MARYLAND TO NEAR SYLVAN, PA.

Sylvan, 1.5 miles south of, in south side of Yeakle mill, near southwest corner, 5 feet above ground, in foundation stone; aluminum tablet stamped "407 C"	466.835

MERCERSBURG QUADRANGLE.

CHAMBERSBURG TO LOUDON.

St. Thomas, in northeast cornerstone of brick hotel; bronze tablet stamped "645 HARRISBURG 1900"	644.835

LOUDON TO RICHMOND.

Loudon, 1.25 miles north of, east side of capstone of culvert; chiseled cross	617.14
Richmond, in southeast cornerstone of schoolhouse foundation; bronze tablet stamped "676 HARRISBURG 1900"	676.346

LOUDON, VIA MERCERSBURG JUNCTION, TO MERCERSBURG.

Mercersburg, 2.5 miles northeast of, at southeast corner of railroad bridge over west branch of Conococheague Creek; capstone, chiseled square	536.96

MERCERSBURG TO COVE GAP.

	Feet.
Mercersburg, 1.75 miles west of, Fruit Hill schoolhouse near northwest corner of foundation; chiseled cross	705.23

MERCERSBURG, VIA UPTON, TO GREENCASTLE.

Mercersburg, Mercersburg Academy, in northwest corner of dining hall; aluminum tablet stamped "595 HARRISBURG 1900"	595.029
Mercersburg, 1 mile east of, stone in front of tollgate house; chiseled cross	558.03
Upton, in southeast cornerstone of brick schoolhouse; aluminum tablet stamped "620 HARRISBURG 1900"	619.834
Greencastle, 0.75 mile west of, schoolhouse at corner of roads, in foundation stone; chiseled cross	550.84

BEDFORD, BLAIR, AND HUNTINGDON COUNTIES.

EVERETT, HOLLIDAYSBURG, AND HUNTINGDON QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet placed in the front of the State Library at Harrisburg, Pa., stamped "364 HARRISBURG 1899," the elevation of which is now accepted as 363.975 feet above mean sea level in accord with the latest adjustment. The initial points upon which these levels depend are various bench marks along precise-level lines of the Pennsylvania Railroad.

The leveling on the Everett and Hollidaysburg quadrangles was done in 1900, and that on the Huntingdon quadrangle was done in 1901, under the direction of Mr. A. M. Walker, topographer, by Mr. F. M. Taylor, levelman. The standard bench marks dependent on this datum are stamped with the letters "HARRISBURG" in addition to the figures of elevation.

EVERETT QUADRANGLE.

MOUNT DALLAS, VIA HUNTINGDON AND BROADTOP RAILROAD, TO COVE.

	Feet.
Mount Dallas, Pennsylvania Railroad bridge over Juniata River, southwest abutment; chiseled square in stone	1,046.49
Everett, in northeast corner of front wall of Union Hotel; aluminum tablet stamped "1015 HARRISBURG"	1,016.853
Everett, 2.7 miles north of, Huntingdon and Broadtop Railroad bridge over highway and stream, southeast corner top stone of north abutment; bronze tablet stamped "1097 HARRISBURG"	1,097.766
Cypher station, 1,310 feet east of, iron railroad bridge over Juniata River, west wing wall, coping stone; chiseled square	928.09
Cypher, 2.6 miles north of, 300 feet west of eleventh milepost, stone culvert near water station, east wing wall; chiseled square	897.22
Hopewell, 75 feet north of station, I. O. O. F. Block, in southwest corner of south wall; bronze tablet stamped "902 HARRISBURG"	901.828
Riddlesburg, 500 feet north of station, stone culvert over creek, on southeast corner coping stone; chiseled square	860.82
Saxton, corner of Church and Litetis streets, in center of north wall of schoolhouse; aluminum tablet stamped "918 HARRISBURG"	917.664
Saxton, 1.5 miles north of, culvert over highway, northeast corner of east abutment, coping stone; chiseled square	877.21
Foxton post-office, Cove station, stone culvert over creek and highway, east wall, 3 feet above surface of highway; bronze tablet stamped "906 HARRISBURG"	906.118

HENRIETTA, WEST TO CURRYVILLE, THENCE SOUTH, ALONG RAILROAD, TO STEELTOWN.

Woodbury, brick schoolhouse, at northwest corner of foundation; bronze tablet stamped "1292 HARRISBURG"	1,291.444
Loysburg, northeast corner front foundation of M. E. Church; bronze tablet stamped "1127 HARRISBURG"	1,126.794
Steeltown, 0.1 mile northeast of, bottom step of front entrance to Steele's flouring mill, square stone; chiseled mark	937.95

HOLLIDAYSBURG QUADRANGLE.

HENRIETTA, VIA MARTINSBURG AND HOLLIDAYSBURG, TO ALTOONA, BEING SPUR LINES FROM PENNSYLVANIA RAILROAD BENCH MARKS.

	Feet.
Henrietta, foundation at north end of Pennsylvania Railroad passenger station shelf in rock (Pennsylvania Railroad bench mark No. 20)	1,394.29
Henrietta, passenger station of Morrisons Cove Branch of Pennsylvania Railroad, corner of foundation; bronze tablet stamped "1393 HARRISBURG"	1,392.959
Martinsburg, Morrisons Cove Bank, north wall, northeast corner of foundation stone; bronze tablet stamped "1407 HARRISBURG"	1,407.250
Roaring Spring, Church of God, corner stone of northwest corner of building; bronze tablet stamped "1237 HARRISBURG"	1,236.603
Hollidaysburg, Blair County court-house, near soldiers' monument, northeast corner of front wall of foundation; aluminum tablet stamped "1010 HARRISBURG"	1,010.274
Canaan station, Pennsylvania Railroad, red brick schoolhouse, in front wall, 3 feet west of door; bronze tablet stamped "1075 HARRISBURG"	1,075.001

MARTINSBURG, VIA WILLIAMSBURG, TO FRANKLIN FORGE.

Martinsburg, 0.75 mile south of, north leg of east end of culvert, in top stone; copper bolt (Pennsylvania Railroad bench mark No. 16)	1,343.12

HUNTINGDON QUADRANGLE.

Williamsburg, northwest corner of brick schoolhouse, in corner stone; bronze tablet stamped "884 HARRISBURG"	884.287
Franklin Forge, south abutment of Bridge No. 24, southea st corner of bridge seat; bronze tablet stamped "862 HARRISBURG"	862.225

HUNTINGDON, SOUTHWEST VIA PUBLIC ROAD AND BROADTOP MOUNTAIN RAILROAD (VIA ENTRIKEN), TO COVE STATION (FOXTON POST-OFFICE).

Huntingdon, Pennsylvania Railroad station, ladies' waiting room, on east window sill; chiseled square	624.47
McConnellstown, front face of brick hall and band room; bronze tablet stamped "716 HARRISBURG"	715.350
Marklesburg (James Creek post-office), front face of brick schoolhouse; aluminum tablet stamped "917 HARRISBURG"	916.671
Foxton (Cove station), in face of north wall of overhead bridge; bronze tablet stamped "906 HARRISBURG 1901"	906.118

ENTRIKEN, SOUTHEAST ALONG HIGHWAY TO CASSVILLE, THENCE NORTH TO HUNTINGDON.

Trough Creek, 2 miles north of, at Paradise furnace, H. P. Reynolds's stock farm, southwest corner of foundation of large barn, in south face of corner stone; bronze tablet stamped "959 HARRISBURG"	959.336
Cassville, 100 feet east of post-office, northwest corner of brick store of Sarah A. Heaton; bronze tablet stamped "1247 HARRISBURG"	1,246.490
Finks Bridge, 2.5 miles east of, on south side of road; point on top of large rock stamped "U" on east side and "P" on west side (township boundary post)	1,670.52
Hawns Bridge, 500 feet east of, at Lutheran brick church, in face of stone doorstep of entrance; aluminum tablet stamped "664 HARRISBURG 1901"	664.333
Huntingdon, in water table near main entrance of court-house; aluminum tablet stamped "642 HARRISBURG 1901"	642.319

CENTER, CLEARFIELD, INDIANA, AND JEFFERSON COUNTIES.

CLEARFIELD, CURWENSVILLE, HOUTZDALE, MARION CENTER, PUNXSUTAWNEY, AND PHILIPSBURG QUADRANGLES.

The elevations in the following lists are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, Pa., marked "738 PITTSBURG 1899", the elevation of which is now accepted as 738.384 feet above mean sea level. The initial points upon which these levels depend are various bench marks along precise-level lines of the Pennsylvania Railroad, the heights accepted having been determined by the 1903 adjustment.

The double-rodded line from Tyrone through these quadrangles was run in 1902 under the direction of Mr. Frank Sutton, by Mr. Ira M. Flocker, levelman, and the remainder of the work on the Houtzdale and Curwensville quadrangles was done in 1902 under the direction of Mr. Sutton, by Mr. Charles Hartman, jr., levelman. The remainder of the work on the Punxsutawney quadrangle was done in 1902 by Mr. George Seidel, levelman. All standard bench marks dependent on this datum are stamped "PITTSBURG" in addition to the figures of elevation.

PHILIPSBURG QUADRANGLE.

	Feet.
Summit, 800 feet south of, 300 feet south of milepost 13, Pennsylvania and Northwestern Railroad, west of track, top of bank, in top of stone; bronze tablet stamped "2045 PITTS"	2,044.653
Philipsburg, in northeast capstone of bridge over Moshannon Creek; aluminum tablet stamped "1428 PITTSBURG"	1,427.768

HOUTZDALE QUADRANGLE.

OSCEOLA MILLS, ALONG PENNSYLVANIA AND NORTHWESTERN RAILROAD, TO BECCARIA.

Osceola Mills, highway bridge over Moshannon Creek, in southeast wing wall; aluminum tablet stamped "1461 PITTSBURG"	1,460.491
Sterling, 0.1 mile southwest of, 0.5 mile northeast of Houtzdale, Bridge No. 304, in south end of west abutment; aluminum tablet stamped "1500 PITTS"	1,499.613
Houtzdale, crossing at station; top of rail	1,518
McCauley, crossing at station; top of rail	1,535
West Moshannon, crossing at station; top of rail	1,540
Kendrick, crossing at station; top of rail	1,553
Beulah, crossing at station; top of rail	1,575
Smoke Run, 0.1 mile east of, Bridge No. 309, in north end of east abutment; aluminum tablet stamped "1351 PITTS"	1,351.033
Beccaria, at crossing; top of rail	1,374

OSCEOLA MILLS, NORTH ALONG PENNSYLVANIA RAILROAD AND BEECH CREEK RAILROAD.

Blueball, corner stone of water-tank house, beside station; bronze tablet stamped "1544 PITTSBURG"	1,543.710
Woodland, 200 feet north of station, in southeast capstone of Pennsylvania Railroad Bridge No. 217; bronze tablet stamped "1463 PITTSBURG"	1,463.024

CLEARFIELD JUNCTION, SOUTH ALONG BEECH CREEK RAILROAD, CLEARFIELD RAILROAD, PUBLIC ROADS, AND PENNSYLVANIA RAILROAD, VIA CLEARFIELD BRIDGE, FAUNCE, AND BELSENA MILLS, TO SMOKE RUN.

Clearfield Bridge, 1.3 miles north of, railroad Bridge No. 28, near crossing, on northwest capstone; chiseled square	1,163.20
Clearfield Bridge, over Clearfield Creek, in northwest capstone of highway bridge; bronze tablet stamped "1172 PITTSBURG"	1,171.936
Faunce, in northwest capstone of highway bridge over Clearfield Creek; bronze tablet stamped "1250 PITTSBURG"	1,250.023
aunce, 3.25 miles west of, southwest corner of church; cut on top of foundation wall	1,613.31
Belsena Mills, in northeast capstone of turntable; bronze tablet stamped "1335 PITTSBURG"	1,334.597
Smoke Run, in southeast top capstone of railroad Bridge No. 39; aluminum tablet stamped "1351 PITTSBURG"	1,351.033
Susquehanna Bridge, railroad station, Pennsylvania Railroad bridge over Susquehanna River on northeast capstone; chisel mark	1,125.03

CURWENSVILLE QUADRANGLE.

COALPORT, ALONG PENNSYLVANIA AND NORTHWESTERN RAILROAD, TO MAHAFFEY.

Coalport, 0.5 mile northwest of, Cambria and Clearfield Railroad bridge across Clearfield Creek, north abutment, east end bridge seat; bronze tablet stamped "1378 PITTS"	1,377.565
Irvona, road crossing at station; top of rail	1,380
Berwinsdale crossing at station; top of rail	1,553
Berwinsdale, 0.2 mile northwest of, in west end of south abutment of culvert, in corner stone; aluminum tablet stamped "1543 PITTS"	1,542.806
Lajose, crossing east of station; top of rail	1,315

	Feet.
Lajose, between, and Lajose junction, railroad Bridge No. 33, in northwest coping stone; aluminum tablet stamped "1297 PITTS"	1,296.501
Ostend, at crossing; top of rail	1,387
Mahaffey, Pennsylvania and Northwestern Railroad bridge over Susquehanna River, in coping stone at east end, south abutment; aluminum tablet stamped "1272 PITTS"	1,271.713

MAHAFFEY, EAST ALONG NEW YORK CENTRAL AND HUDSON RIVER RAILROAD, TO CLEARFIELD BRIDGE.

Curry Run, railroad bridge over Susquehanna River, in north end south abutment; bronze tablet stamped "1222 PITTS"	1,221.275
Kerrmoor, 0.1 mile west of, in north end south abutment of railroad Bridge No. 44; bronze tablet stamped "1356 PITTS"	1,355.957
Olanta, in northwest abutment of highway bridge over Clearfield Creek; bronze tablet stamped "1296 PITTSBURG"	1,295.256

CURWENSVILLE, ALONG PENNSYLVANIA RAILROAD, TO GRAMPIAN.

Curwensville, 0.2 mile east of, in step of abutment of Buffalo, Rochester and Pittsburg Railroad bridge; bronze tablet stamped "1143 PITTS"	1,142.668
Grampian, highway bridge over Little Anderson Creek, in southeast capstone of east abutment; bronze tablet stamped "1535 PITTSBURG"	1,535.225

LAJOSE, SOUTH ALONG PENNSYLVANIA RAILROAD, TO WESTOVER.

Westover, northwest corner of Baptist Church, top cornerstone of foundation, in west face; bronze tablet stamped "1368 PITTSBURG"	1,368.114

CLEARFIELD QUADRANGLE.

CLEARFIELD JUNCTION, NORTH ALONG PENNSYLVANIA RAILROAD, TO CLEARFIELD.

Clearfield, 2.3 miles south of, Pennsylvania Railroad bridge over the New York Central and Hudson River Railroad; chiseled cut in abutment	1,129.40
Clearfield, 0.1 mile south of office of New York Central and Hudson River Railroad station, highway bridge over the Susquehanna River, in coping of the northeast wing abutment; aluminum tablet stamped "1113 PITTSBURG"	1,112.386
Riverview, highway bridge over Susquehanna River, on the southwest capstone; chiseled mark	1,113.14

PUNXSUTAWNEY QUADRANGLE.

M'GEES MILLS, ALONG PENNSYLVANIA AND NORTHWESTERN RAILROAD, TO PUNXSUTAWNEY.

McGees Mills, in front of station; top of rail	1,307
Sydney, 0.5 mile northwest of, in top of rock, east of track; bronze tablet stamped "1622 PITTS"	1,621.624
Flynn, crossing; top of rail	1,608
Winslow, southeast corner of station, in top of stone; aluminum tablet stamped "1649 PITTS"	1,648.127
Elbell, crossing at station; top of rail	1,483
Canoe Creek, crossing at station; top of rail	1,260
Punxsutawney, in northeast wing wall of Mahoning Street Bridge; aluminum tablet stamped "1236 PITTS"	1,235.906
Punxsutawney, in front of station; top of rail	1,236

CHERRY TREE (GRANT POST-OFFICE), NORTH ALONG PUBLIC ROAD AND RAILROAD, VIA PATCHINSVILLE AND BURNSIDE, TO M'GEES MILLS.

Patchinsville, grain house opposite post-office, southwest corner of foundation wall; aluminum tablet stamped "1370 PITTS"	1,369.367
Burnside, upper iron bridge over river, northwest abutment; bronze tablet stamped "1328 PITTS"	1,327.388
Glen Campbell, abutment of Bridge No. 42, at intersection of Brady Run and Cush Creek; bronze tablet stamped "1344 PITTS"	1,343.830

ROSSITER JUNCTION, SOUTH ALONG RAILROAD AND PUBLIC ROADS, VIA ROSSITER STATION AND ROCHESTER MILLS, TO ORD POST-OFFICE.

	Feet.
Rossiter station, 350 feet north of, west side of track, west end of culvert; copper bolt stamped "1324 PITTS"	1,323.595
Rochester Mills (Richmond), iron bridge[a] over Little Mahoning Creek, southwest abutment; bronze tablet (stamping obliterated)	1,273
East Run, 0.2 mile west of post-office; south side of road, flat rock near blacksmith shop; aluminum tablet stamped "PITTS 1539"	1,538.203

MARION CENTER QUADRANGLE.

VALIER, ALONG PENNSYLVANIA AND NORTHWESTERN RAILROAD, TO GOODVILLE.

Valier, road crossing; top of rail	1,225
Hamilton, road crossing; top of rail	1,190
Hamilton, 60 feet west of, 5 feet south of track, in top of large rock; aluminum tablet stamped "1188 PITTSBURG"	1,187.045
Loop, 0.25 mile west of; high bridge over Mahoning Creek, in south end of east abutment; aluminum tablet stamped "1183 PITTS"	1,182.458
Goodville, crossing at station; top of rail	1,215
Dayton, 900 feet west of station, northwest wing wall of Buffalo, Rochester and Pittsburg Railroad bridge over small stream, on second coping stone; aluminum tablet stamped "1326 PITTSBURG"	1,326.118

BEDFORD, BLAIR, CAMBRIA, INDIANA, AND SOMERSET COUNTIES.

ALTOONA, BARNESBORO, BEDFORD, EBENSBURG, JOHNSTOWN, PATTON, AND TYRONE QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, Pa., marked "738 PITTSBURG," 1899, the elevation of which is now accepted as 738.384 feet above mean sea level. The initial points upon which these levels depend are various bench marks along the precise-level lines of the Pennsylvania Railroad, the accepted heights having been determined by the 1903 adjustment.

The work on the Barnesboro quadrangle was done under the direction of Mr. Frank Sutton, topographer; partly in 1901 by Mr. J. H. Wetzel, levelman, and partly in 1902 by Mr. George Seidel, levelman. Mr. Seidel also did the leveling on the Johnstown quadrangle in 1902. The work on the Bedford and Ebensburg quadrangles was done in 1901 under the direction of Mr. A. M. Walker, topographer, by Mr. J. B. McGuire, levelman. The Patton quadrangle was partly leveled in 1901 by Mr. F. M. Taylor, levelman, under the direction of Mr. A. M. Walker, topographer, the work being completed in 1902 by Mr. Charles Hartman, jr., levelman, under the direction of Mr. Frank Sutton, topographer. All standard bench marks dependent upon this datum are stamped "PITTSBURG" in addition to the figures of elevation.

TYRONE QUADRANGLE.

TYRONE, ALONG PENNSYLVANIA RAILROAD AND PENNSYLVANIA AND NORTHWESTERN RAILROAD, TO VANSCOYOC (DOUBLE-RODDED LINE).

	Feet.
Tyrone, in front of passenger station; chiseled shelf in base course (Pennsylvania Railroad bench mark No. 110)	910.69
Tyrone, 2 miles north of, northeast wing wall of Bridge No. 5; chiseled square	941.28
Vail, in front of station; top of rail	989
Vanscoyoc, just southeast of, 100 feet southeast of cut, 15 feet north of track; chiseled square in top of rock	1,395.80

ALTOONA QUADRANGLE.

Utahville, in front of station; top of rail	1,669

[a] Owing to reconstruction of this bridge the elevation may be erroneous.

PATTON, EAST ALONG PUBLIC ROAD, TO FRUGALITY.

	Feet.
Frugality, 0.25 mile south of, west end of south abutment of railroad Bridge No. 408, at junction of wye track, on capstone; chiseled cross	1,475.53

PATTON QUADRANGLE.

Coalport, crossing at station; top of rail	1,414

GALLITZIN, NORTHWEST VIA PUBLIC ROAD TO LORETTO, THENCE WEST TO EBENSBURG.

Loretto, northeast corner of Catholic Church, on corner of lowest step; cross cut	1,942.60
Winterset station, at road crossing; top of north rail	2,111

LORETTO,[a] VIA PUBLIC ROAD TO PATTON, THENCE WEST TO ELMORA.

Chest Springs, southeast corner of frame schoolhouse, on corner stone of foundation; bronze tablet stamped "1969 HARRISBURG"	1,968.699
Patton, 2 miles southeast of, Clarke schoolhouse, southeast corner of cloak room, on face of foundation corner stone; cross cut	1,945.83
Patton, main entrance to Good Building, stone at right side; aluminum tablet stamped "1756 PITTSBURG"	1,755.348
Carrolltown, at left entrance steps to St. Benedict's Catholic Church, on corner stone of foundation wall; square and cross cut	2,173.32
Elmora, 600 feet south of, in valley, southwest corner of schoolhouse, in foundation stone; aluminum tablet stamped "1765 PITTSBURG"	1,764.016

PATTON, VIA PUBLIC ROAD, NORTH TO HASTINGS, THENCE WEST TO BARNESBORO.

Hastings, opera house, northeast corner of foundation, north face of top corner stone; aluminum tablet stamped "1736 HARRISBURG"	1,734.553

HASTINGS, NORTH ALONG HIGHWAY, TO WESTOVER.

Garway, 1.7 miles north of, north side of railroad Bridge No. 28, on masonry; chiseled cross	1,360.90

FRUGALITY, SOUTH ALONG CAMBRIA AND CLEARFIELD RAILROAD, TO SYBERTON

Frugality, 2.5 miles south of, crossing at Dean station, 100 feet south of north abutment of railroad bridge No. 407, west capstone; chiseled square	1,514.30
Ashville, 0.1 mile south of, on last capstone middle pier of railroad Bridge No. 403; chiseled square	1,643.41
Syberton, 0.25 mile west of, east abutment of iron bridge across Clearfield Creek, on west coping stone of north corner; cross cut	1,764.85

BARNESBORO QUADRANGLE.

Cookport, southwest of McCoy's store, top of stone over cellar door; aluminum tablet stamped "1609 PITTSBURG"	1,606.662

COOKPORT, EAST ALONG PUBLIC ROADS, TO CHERRY TREE (GRANT POST-OFFICE).

Cherry Tree, railroad Bridge No. 314, southeast end of bridge seat; aluminum tablet stamped "1366 PITTSBURG"	1,363.983

CHERRY TREE (GRANT POST-OFFICE), ALONG RAILROAD, VIA BARNESBORO AND ELMORA, TO EBENSBURG.

Barnesboro, 0.1 mile north of station, south abutment of railroad Bridge No. 308, in east end of bridge seat; aluminum tablet stamped "1447 PITTSBURG"	1,445.641

EBENSBURG, WEST ALONG ROAD VIA PINDLETON AND STRONGSTOWN, TO PENN RUN.

Pindleton post-office, in southeast corner of foundation of church; aluminum tablet stamped "2301 PITTSBURG"	2,299.683
Strongstown, in southeast corner of Methodist church; aluminum tablet stamped "1890 PITTSBURG"	1,889.475
Greenville, 4 miles southeast of 2.5 miles north of Nolo, southwest corner of large barn of M. A. Sleepy, in top of large stone; aluminum tablet stamped "1725 PITTSBURG"	1,724.600

[a] Loretto is checked by two other lines from Cresson.

JOHNSTOWN QUADRANGLE.

JOHNSTOWN, SOUTH ALONG BALTIMORE AND OHIO RAILROAD, TO INGLESIDE.

	Feet.
Johnstown, at west end of north parapet of railroad bridge; copper bolt (Pennsylvania Railroad bench mark)	1,180.27
Johnstown, east end of south parapet of Pennsylvania Railroad bridge; aluminum tablet stamped "1180 PITTS"	1,180.261
Johnstown, railroad ticket office, on window sill; chiseled shelf (Pennsylvania Railroad bench mark)	1,187.60
Johnstown, road crossing at Pennsylvania Railroad station; top of rail	1,184
Johnstown, in front of Baltimore and Ohio Railroad station; top of rail	1,169
Honey Creek, road crossing at station; top of rail	1,194
Johnstown, 3 miles south of, Baltimore and Ohio Railroad and trolley grade crossing; top of rail	1,191
Kring, road crossing at station; top of rail	1,241
Ingleside, 700 feet north of, northeast corner of small railroad bridge; copper bolt marked "1275 PITTS"	1,275.610

INGLESIDE, NORTHEAST ALONG PENNSYLVANIA RAILROAD, VIA ELKTON, TO SALIX.

Scalp Level, 0.45 mile north of, west side of track, 75 feet west of tool house, in large sandstone; aluminum tablet stamped "1719 PITTS"	1,719.225
Salix, 870 feet north of station, under Pennsylvania Railroad culvert, west wall; bronze tablet stamped "2050 PITTS"	2,049.455
Salix, railroad bridge at station, north parapet, east end; aluminum tablet stamped "2077 PITTS"	2,077.762

SEWARD, NORTHEAST ALONG PENNSYLVANIA RAILROAD, VIA VINTONDALE AND NANTY GLO, TO EBENSBURG.

Seward, 0.17 mile west of V. K. tower, railroad Bridge No. 226 over Piney Run, north parapet, east end of arch; copper bolt (Pennsylvania Railroad bench mark)	1,091.571
Seward, doorstep of waiting room of station; copper bolt marked "1122 U. S"	1,122.145
Seward, crossing at station; top of rail	1,120
Wehrum, crossing at station; top of rail	1,360
Vintondale, 150 feet east of station, iron bridge, south end of west abutment; aluminum tablet stamped "1403 PITTS"	1,402.741
Twin Rocks, crossing at station; top of high rail	1,668
Nanty Glo, 200 feet south of station, iron bridge, west end of north abutment; bronze tablet stamped "1706 PITTS"	1,705.761
Nanty Glo, crossing at station; top of high rail	1,710
Beulah Road, in front of station; top of rail	1,894

EBENSBURG QUADRANGLE.

AT EBENSBURG (ON LINE FROM GALLITZIN).

Ebensburg, west front of court-house, in base of center column of double entrance; aluminum tablet stamped "2138 PITTSBURG"	2,138.223

WILMORE, SOUTH ALONG PUBLIC ROADS AND PENNSYLVANIA RAILROAD, TO SALIX.

Wilmore, in front wall of railroad station; chiseled square (Pennsylvania Railroad bench mark No. 14)	1,562.72
Wilmore, 1,090 feet north of station, highway bridge over creek, in south end of east abutment; bronze tablet stamped "1555 PITTS"	1,554.389
Lovett, 0.7 mile south of, east end of north parapet of railroad bridge; copper bolt stamped "1725 U. S"	1,724.992

LOVELY, NORTH ALONG PUBLIC ROADS, TO BLUE KNOB, THENCE NORTHWEST TO PORTAGE.

Pavia, highway bridge over Bobs Creek, in east end of face of north abutment; bronze tablet stamped "1403 PITTSBURG"	1,402.449
Blue Knob, at southeast corner of crossroads, on east end of north wall of Mount Sinai Church; bronze tablet stamped "2375 PITTSBURG"	2,373.830
Blue Knob,[a] Union Township, Bedford County, 2.5 miles northeast of Pavia post-office	3,136
Hughes mine tipple, 10 feet west side of track, on top of bowlder; chiseled cross	1,814.51

[a] A flying-level spur line run from Blue Knob post-office to the summit of Blue Knob determined this elevation, which is the highest known in the State of Pennsylvania. It is about 4 miles east of the main crest of the Allegheny Plateau and 200 feet higher.

BEDFORD QUADRANGLE.

ELTON, SOUTHEAST ALONG PUBLIC ROADS, TO LOVELY.

	Feet.
Elton, 8.9 miles east of, 2,000 feet from top on side of Allegheny Mountains, on west side of New Road; chiseled square on rock	2,591.35
Lovely, southeast corner of crossroads, at northwest corner of post-office building; bronze tablet stamped "1314 PITTSBURG"	1,312.901

CLARION AND JEFFERSON COUNTIES.

CLARION, BROOKVILLE, AND FOXBURG QUADRANGLES.

The elevations in the following list are based upon bench marks at Parker and Redbank on the Geological Survey precise-level line Franklin to Pittsburg which traverses the Foxburg quadrangle. The leveling was done in 1905 under the direction of Mr. W. T. Griswold, topographer, by Mr. B. J. Green, levelman. The standard bench marks are stamped "ADJ 1903" in addition to the figures of elevation.

FOXBURG QUADRANGLE.

PARKER, NORTHEAST ALONG BALTIMORE AND OHIO RAILROAD (NARROW GAGE), TO SHIPPENVILLE.

	Feet.
Foxburg, in stone doorsill of baggage room at Pennsylvaina station; copper bolt	892.544
Foxburg, in east wall near entrance to "The Inn," opposite station; aluminum tablet stamped "885 ADJ 1903"	884.494
Richmond (Alum Rock post-office), opposite, in doorstep of hotel building; bronze tablet stamped "1190 ADJ 1903"	1,190.389
Blairs Corners, 1,000 feet east of, bridge over Beaver Run, north end of west abutment, by flouring mill; bronze tablet stamped "1157 ADJ 1903"	1,156.826
Knox, at southeast corner of Main and State streets, in foundation wall at northeast corner of B. A. Kribbs & Co.'s brick building; aluminum tablet stamped "1382 ADJ 1903"	1,381.839

CLARION QUADRANGLE.

SHIPPENVILLE, SOUTHEAST ALONG PITTSBURG, SOMERVILLE AND CLARION RAILROAD, TO HOLDEN.

Shippenville, 0.5 mile northwest of, on north end of east abutment of iron county bridge over Deer Creek; aluminum tablet stamped "1209 ADJ 1903"	1,208.296
Clarion Junction, 25 feet in front of entrance to schoolhouse, in rock; bronze tablet stamped "1439 ADJ 1903"	1,438.990
Clarion, 1.3 miles northwest of, in coping at southeast corner of large iron bridge over Clarion River; bronze tablet stamped "1088 ADJ 1903"	1,088.020
Clarion, in north meridian stone near northwest corner of court-house; bronze tablet stamped "1491 ADJ 1903"	1,490.687
Clarion, in south meridian stone in southeast corner of park opposite court-house; bronze tablet stamped "1485 ADJ 1903"	1,484.668
Strattonville, 1,500 feet south of, on south end of east abutment of railroad bridge over county road; aluminum tablet stamped "1438 ADJ 1903"	1,437.542
Holden, 1.6 miles west of, in south end of abutmer t of railroad bridge over Piney Creek; bronze tablet stamped "516 ADJ 1903"	1,515,276

HOLDEN, WEST ALONG HIGHWAY TO NEAR SLIGO, THENCE NORTH TO ELK CITY.

Kingsville, in foundation wall at southwest corner of M. G. May's store and post-office building; aluminum tablet stamped "1387 ADJ 1903"	1,386.944
Greenville (Limestone post-office), in foundation wall at northwest corner of flouring mill; aluminum tablet stamped "1270 ADJ 1903"	1,269.697
Greenville, 4 miles west of, 2.5 miles south of Reidsburg, in south foundation wall at southwest corner of J. Monreau's dwelling; aluminum tablet stamped "1325 ADJ 1903"	1,324.660
Burma, 1,000 feet south of, in west foundation of Five Point schoolhouse; aluminum tablet stamped "1279 ADJ 1903"	1,278.874
Piney, on north wing wall of south abutment of large iron bridge over Clarion River; aluminum tablet stamped "1022 ADJ 1903"	1,021.831
Elk City, 3.3 miles south of, in north foundation wall of Madison schoolhouse at crossroads; aluminum tablet stamped "1477 ADJ 1903"	1,476.129

LAWSONHAM, NORTH ALONG SLIGO BRANCH OF PENNSYLVANIA RAILROAD, TO SLIGO.

	Feet.
Rimersburg, 1.1 miles southeast of station, in north hill pier of coal tipple of Acme Coal Company; aluminum tablet stamped "1269 ADJ 1903"	1,268.544
Cherry Run (Huey post-office), in southeast corner of foundation wall of station, post-office, and store building; bronze tablet stamped "1241 ADJ 1903"	1,240.605
Sligo, at northwest corner of Main and Clarion streets, in doorsill of H. Holdid's brick store building; aluminum tablet stamped "1159 ADJ 1903"	1,158.415

AT LEATHERWOOD. (ON LINE LAWSONHAM TO CLIMAX, WHICH IS MOSTLY IN RURAL VALLEY QUADRANGLE.)

Leatherwood, in large rock 50 feet south of station; aluminum tablet stamped "1000 ADJ 1903"	999.326

CLIMAX, EAST ALONG PENNSYLVANIA RAILROAD (LOW-GRADE DIVISION) TO MAYPORT. (MEAN OF THREE LINES INCLUDING RAILROAD LEVELS.)

Bethlehem, 0.5 mile west of, in southeast corner of south coping of stone-arch bridge opposite South Bethlehem; aluminum tablet stamped "1067 ADJ 1903"	1,066.693
New Bethlehem, in baggage-room doorsill; copper bolt (railroad bench mark marked 1077.83 B. M.)	1,077.101
Oak Ridge, 0.6 mile west of, in coping at northeast corner of Bridge No. 58; copper bolt (railroad bench mark marked 1086.56 B. M.)	1,085.826
Oak Ridge, at northeast corner of Bridge No. 57, over county road near station; aluminum tablet stamped "1089 ADJ 1903"	1,088.401
Mayport, 0.7 mile west of, in coping at north end of east abutment of Bridge No. 56; copper bolt (railroad bench mark)	1,096.723
Mayport, in north end of east abutment of Bridge No. 55; copper bolt (railroad bench mark)	1,104.796

BROOKVILLE QUADRANGLE.

HOLDEN, SOUTHEAST ALONG PITTSBURG, SUMMERVILLE AND CLARION RAILROAD, TO SUMMERVILLE, THENCE SOUTHWEST ALONG PENNSYLVANIA RAILROAD (LOW-GRADE DIVISION) TO MAYPORT. (MEAN OF TWO LINES.)

Holden, 1.2 miles southeast of, on east end of south abutment of small bridge just south of private crossing (county road 75 feet east); aluminum tablet stamped "1433 ADJ 1903"	1,432.338
Summerville, on northwest corner of railroad bridge over Redbank Creek; aluminum tablet stamped "1160 ADJ 1903"	1,159.890
Heathville, in coping at west end of north abutment of Bridge No. 51, over Beaver Run; aluminum tablet stamped "1158 ADJ 1903"	1,157.456
Heathville, 0.7 mile southwest of, in coping at northwest corner of north abutment of Bridge No. 52, over Redbank Creek; railroad bench mark 1154.69	1,153.994
Pattons Station post-office, in north pier of water tank; copper bolt stamped "1137.255"	1,136.554
Mayport (New Mayville post-office), 1 mile east of, in north coping of stone-arch bridge over run and road; aluminum tablet stamped "1108 ADJ 1903"	1,106.892

ARMSTRONG, BUTLER, AND INDIANA COUNTIES.

KITTANNING AND RURAL VALLEY QUADRANGLES.

The elevations in the following list are based upon bench marks at Kittanning, Rimerton, and East Brady, on the precise-level line from Erie to Pittsburg, and are determined in accord with the latest adjustment of the precise-level net. For additional elevations on these quadrangles refer to said precise line.

The leveling on the Rural Valley quadrangle, republished from Bulletin No. 185, was done in 1900 under the direction of Mr. Frank Sutton, topographer, by Mr. J. H. Wetzel, levelman, and that on the Kittanning quadrangle was mostly done in the same year under the direction of Mr. W. L. Miller, topographer, by Mr. Ira M. Flocker, levelman. The elevations between Climax and Redbank on these quadrangles were determined in 1905 under the direction of Mr. W. T. Griswold, topographer, by Mr. B. J. Green, levelman. The standard bench marks are stamped with the letters "PITTSBURG" in addition to the figures of elevation, except those set in 1905, which are stamped "ADJ 1903" in addition to the figures of elevation.

RURAL VALLEY QUADRANGLE.

KITTANNING, VIA RURAL VALLEY AND DAYTON, TO MAHONING.

	Feet.
Kittanning, 4.5 miles east of, 50 feet east of road northeast, north side of road, on rock; chiseled square	1,026.19
Kittanning, 5 miles east of, southeast corner stone of stone house; aluminum tablet stamped "1011 PITTSBURG"	1,010.491
Rural Valley, southeast wing wall of bridge, in coping stone; bronze tablet stamped "1112 PITTSBURG"	1,111.610
Dayton, 900 feet west of station, Buffalo, Rochester and Pittsburg Railroad bridge over small stream, on second coping stone of northwest wing wall; aluminum tablet stamped "1326 PITTSBURG"	1,326.118
Eddyville, 2 miles south of, on southeast abutment of iron bridge over Mahoning Creek; chiseled square "1019"	1,018.69
Eddyville, iron bridge over Big Mahoning, on bridge seat, southeast wing wall; aluminum tablet stamped "992 PITTSBURG"	992.284
Putneyville, iron bridge over Mahoning Creek, on coping stone of northwest wing wall; chiseled square	940.42
Mahoning, 6 miles east of, iron bridge over Mahoning Creek known as "Macks Bridge;" chiseled square on southeast bridge seat	863.50
Mahoning, 2 miles east of, iron bridge, on coping stone of southwest wing wall; chiseled square	833.17
Mahoning, in front of Allegheny Valley Railroad station; top of rail	818.7
Rimerton, 2 miles south of, northwest abutment of railroad bridge; bronze tablet stamped "820 PITTSBURG 1899"	820,810

CLIMAX, WEST ALONG PENNSYLVANIA RAILROAD (LOW-GRADE DIVISION), TO LAWSONHAM. (LEATHERWOOD IS GIVEN UNDER CLARION QUADRANGLE.)

Climax, in doorsill of Climax Fire Brick Company's office, by station; copper bolt marked "1046.765" (railroad bench mark)	1,045.973
Climax, in foundation wall at southeast corner of Climax Fire Brick Company's office, by station; aluminum tablet stamped "1046 ADJ 1903"	1,045.644
St. Charles, in coping at northeast corner of Bridge No. 63, just east of station; copper bolt marked "1023.595" (railroad bench mark)	1,022.953
Lawsonham, 2.5 miles east of, in west end of arch tunnel; aluminum tablet stamped "946 ADJ 1903"	945.554
Lawsonham, on south coping of arch bridge east of station; copper bolt marked "909.33" (railroad bench mark)	908.833
Lawsonham, on coping at southeast corner of arch bridge just east of station; aluminum tablet stamped "909 ADJ 1903"	908.768

KITTANNING QUADRANGLE.

LAWSONHAM, WEST ALONG PENNSYLVANIA RAILROAD, TO RED BANK.

Shannon, in face of stone milepost at east side of coal tipple, marked "3 and 107"; aluminum tablet stamped "881 ADJ 1903"	880.127
Redbank, 1 mile east of, in coping at northeast corner of Bridge No. 69; copper bolt marked "856.04" (railroad bench mark)	855.64
Redbank, in coping at northwest corner of railroad bridge over Redbank Creek (Allegheny division); copper bolt marked "845.21" (railroad bench mark)	844.786

KITTANNING, WEST ALONG HIGHWAY TO WEST WINFIELD, THENCE NORTH TO CHICORA AND EAST TO EAST BRADY. (THE ERROR DISTRIBUTED IN THIS LINE IS SLIGHTLY EXCESSIVE.)

Kittanning, public schoolhouse; bronze tablet stamped "803 PITTSBURG"	803.500
West Winfield, 100 feet west of railroad tracks, in foundation of trestle; aluminum tablet stamped "950 PGH 1900"	949.940
Fennelton, 375 feet west of station, in foundation of water tank; aluminum tablet stamped "1068 PGH 1900"	1,068.572
Chicora, corner Main street and Central avenue, directly opposite Union Hall, in sandstone post; aluminum tablet stamped "1246 PGH 1900"	1,245.543

INDIANA AND WESTMORELAND COUNTIES.

BOLIVAR, ELDERS RIDGE, INDIANA, AND LATROBE QUADRANGLES.

The elevations published in the following list are based upon various bench marks of the Pennsylvania Railroad on lines from West Penn Junction, via Blairsville intersection, to Braddock, the elevations of which are derived from the latest adjustment by the United States Coast and Geodetic Survey. The work was previously reported upon in Bulletin No. 185.

The leveling was executed under the direction of Mr. Frank Sutton, topographer, by Mr. J. H. Wetzel, levelman, except that on the west side of Elders Ridge quadrangle which was done in 1901 by Mr. Ira M. Flocker, levelman. The bench marks are stamped "PITTSBURG" in addition to the figures of elevation.

LATROBE QUADRANGLE.

SALTSBURG, SOUTH VIA NEW ALEXANDRIA, TO LATROBE.

	Feet.
Saltsburg, wooden covered bridge over Kiskiminitas River, on northeast wing wall, west end; aluminum tablet stamped "849 PITTSBURG"	848.567
New Alexandria, wooden covered bridge over Loyalhanna Creek, southeast wing wall, on coping stone; tablet stamped "945 PITTSBURG"	944.980
New Alexandria, 500 feet north of Pennsylvania Railroad station, east side of road; nail in root of large oak (Pennsylvania Railroad bench mark No. 407)	975.43

FIVE TABLETS SET FROM PENNSYLVANIA RAILROAD BENCH MARKS.

Georges station, on north pier of overhead bridge; aluminum tablet stamped "1199 PITTSBURG"	1,199.180
Latrobe, high school building; aluminum tablet stamped "1026 PITTSBURG"	1,026.206
Millwood, south abutment of overhead bridge, on southwest coping stone; tablet stamped "1175 PITTSBURG"	1,175.286
Livermore, 0.2 mile east of, in southeast wing wall of overhead bridge; aluminum tablet stamped "934 PITTSBURG"	933.462
Blairsville, northeast corner of Pennsylvania passenger station, on foundation off-set; chiseled square (Pennsylvania Railroad bench mark No. 60)	1,011.909
Blairsville, northeast wing wall of Walnut Street Bridge, on coping stone; aluminum tablet stamped "1003 PITTSBURG"	1,003.077

BLAIRSVILLE, ALONG PENNSYLVANIA RAILROAD, VIA HOMER CITY, TO INDIANA.

Blairsville, Maple street crossing; top of rail	1,010.1

BOLIVAR QUADRANGLE.

Turner, in front of station; top of west rail	1,100.1
Black Lick, in front of station; top of west rail	967
Black Lick, 6 miles north of station, railroad bridge over Two Lick Creek, southwest corner of south abutment, on coping stone; bronze tablet stamped "981 PITTSBURG"	980.510
Rugh, in front of station; top of west rail	1,028.5

INDIANA QUADRANGLE.

Graceton, in front of station; top of rail	1,060
Homer, 600 feet south of station, bridge over Yellow Creek, northwest wing wall, on coping stone; aluminum tablet stamped "1019 PITTSBURG"	1,019.092
Homer, in front of station; top of rail	1,023
Two Lick, in front of station; top of rail	1,057.4
Reed, in front of station; top of west rail	1,149.1
Normal, 1 mile south of, northwest wing wall of bridge; chiseled square	1,227.89
Indiana, Normal school campus, on north meridian stone; bronze tablet stamped "1299 PITTSBURG 1900"	1,299.022

INDIANA, VIA CREEKSIDE, GAIBLETON, PENN RUN, AND BRUSH VALLEY, TO HOMER.

	Feet.
Indiana, in front of station; top of west rail	1,309.3
Newville, entrance to M. E. Church, in southwest corner stone; bronze tablet stamped "1034 PITTSBURG"	1,033.678
Gaibleton, 650 feet south of post-office, west side of road, double-arch stone bridge, on coping stone of north arch; aluminum tablet stamped "1087 PITTSBURG"	1,086.388
Tanoma, Tanoma House, in top foundation stone of bay window; aluminum tablet stamped "1132 PITTSBURG"	1,132.225
Tanoma, 4.25 miles south of, southeast wing wall of covered bridge, on coping stone; chiseled square	1,191.61
Penn Run (Greenville), on lower stone step of Presbyterian Church; bronze tablet stamped "1475 PITTSBURG"	1,474.578
Brush Valley, entrance to Union House, in south end of top stone step; bronze tablet stamped "1447 PITTSBURG"	1,448.267

ELDERS RIDGE QUADRANGLE.

CREEKSIDE WEST TO SHELOCTA, THENCE SOUTH VIA KENT TO LIVERMORE.

Shelocta, at west end of covered bridge over Crooked Creek, northeast wing wall, on coping stone; bronze tablet stamped "992 PITTSBURG"	991.414
Kent, 3 miles north of post-office, W. L. Neal's brick house, on upper foundation stone; aluminum tablet stamped "1167 PITTSBURG"	1,167.098
Kent, 2 miles south of post-office, James M. Jack's brick residence, on stone doorstep; bronze tablet stamped "1029 PITTSBURG"	1,028.344

SHELOCTA, ALONG HIGHWAY, VIA ELDERTON, COCHRAN MILLS, AND ELDERS RIDGE, TO JACKSONVILLE (KENT POST-OFFICE).

Shelocta, in wing wall of covered bridge over Crooked Creek; bronze tablet stamped "992 PITTSBURG"	991.414
Elderton, opposite hotel, on street corner, in west side of square hitching post; aluminum tablet stamped "1265 PITTSBURG"	1,264.510
Cochran Mills, old covered bridge over Crooked Creek, in northwest wing wall of east abutment; bronze tablet stamped "871 PITTSBURG"	870.429
Elders Ridge, Presbyterian Church, in southwest corner foundation stone; aluminum tablet stamped "1226 PITTSBURG"	1,225.639
Clarksburg, at corner of front of hotel, on stone; chiseled square	917.85

ELDERS RIDGE TO EDRI.

Edri, 0.1 mile west of station, in northwest corner of bridge seat of railroad bridge; bronze tablet stamped "834 PITTSBURG"	833.732

FAYETTE, GREENE, SOMERSET, WASHINGTON, AND WESTMORELAND COUNTIES.

BROWNSVILLE, CONFLUENCE, CONNELLSVILLE, MASONTOWN, AND UNIONTOWN QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, the elevation of which is now accepted as 738.384 feet above mean sea level. The initial points upon which this work depends are various bench marks on the precise-level line, Grafton to Pittsburg, of the United States Geological Survey, and the Connellsville and Pittsburg division precise level-line of the Baltimore and Ohio Railroad. For additional elevations in these quadrangles refer to list under "Precise leveling." The leveling was previously reported upon partly in the Appendix to the Twenty-first Annual Report and partly in Bulletin No. 185, but has been corrected in this list to accord with the 1903 adjustment.

The leveling on the Uniontown quadrangle, on the west side of the Confluence quadrangle, and on line to Greensboro on the Masontown quadrangle, was done in 1899, under the direction of Mr. Frank Sutton, topographer, by Mr. William Crennell, levelman. The leveling on the Connellsville quadrangle, on line West Newton to Baird on the Brownsville quadrangle, was done the same year, under Mr. Sutton, by Mr. J. H. Wetzel, levelman, who com-

pleted leveling on the Masontown quadrangle in 1900. The line through Centerville on the Brownsville quadrangle was run in 1901, under the direction of Mr. A. H. Bumstead, topographer, by Mr. M. P. Page, levelman. The standard bench marks depending on this datum are stamped "PITTSBURG" in addition to the figures of elevation.

UNIONTOWN QUADRANGLE.

UNIONTOWN, SOUTHEAST ALONG HIGHWAY TO FARMINGTON.

	Feet.
Summit, 75 feet east of steps in front of Summit House, in large bowlder in field south side of National pike, 20 feet south of fence; bronze tablet stamped "2418 PITTSBURG"	2,417.607

FARMINGTON, SOUTHWEST TO ELLIOTTSVILLE.

Elliottsville, in north side of east abutment wing wall of stone-arch bridge over Sandy Creek; bronze tablet stamped "1569 PITTSBURG"	1,569.145

FARMINGTON, NORTHEAST ALONG HIGHWAY TO OHIO PYLE, THENCE NORTHWEST ALONG RAILROAD TO SOUTH CONNELLSVILLE, THENCE SOUTHWEST TO UNIONTOWN.

Farmington, in southwest corner of foundation of Thomas Rush's hotel; bronze tablet stamped "1835 PITTSBURG"	1,835.546
Indian Creek, on south bridge seat, west abutment of Baltimore and Ohio Railroad bridge over Indian Creek; bronze tablet stamped "970 PITTSBURG"	970.195
South Connellsville, on northwest corner of abutment of bridge over Youghiogheny River (Baltimore and Ohio Short Line); chisel mark	914.11
Dunbar, in water table at northeast corner of George Swearingen's store; bronze tablet stamped "999 PITTSBURG"	998.434
Ferguson (flag station), 0.25 mile north of, on west side of north abutment of bridge over creek; chisel mark	1,110.26
Lemont Furnace, in water table at northeast corner of Union Supply Company's store; bronze tablet stamped "1059 PITTSBURG"	1,059.096

MASONTOWN QUADRANGLE.

POINT MARION NORTH TO GREENSBORO.

Point Marion, 3.1 miles north of, on stone in west side of south abutment of bridge over Dunkard Creek; chisel mark	799.93
New Geneva, on west side of north abutment of bridge over creek; chisel mark	793.41
Greensboro, on southeast corner of foundation of Crawford's block; bronze tablet stamped "806 PITTSBURG"	806.464

BROWNSVILLE, SOUTHWEST VIA EAST RIVERSIDE TO CARMICHAELS.

Jacobs Ferry (East Riverside), on southwest corner of foundation of mill; bronze tablet stamped "792 PITTSBURG"	792.615
Carmichaels, on stone step of entrance to schoolhouse; aluminum tablet stamped "1004 PITTSBURG"	1,004.297

CONFLUENCE QUADRANGLE.

Ohiopyle, south face of north abutment of Baltimore and Ohio Railroad bridge over Youghiogheny River; bronze tablet stamped "1218 PITTSBURG"	1,217 632
Somerfield,[a] corner of Main and Water streets, foundation wall of brick building owned by J. W. Endsley; aluminum tablet stamped "1386 C"	1,390.349

CONNELLSVILLE QUADRANGLE.

SOUTH CONNELLSVILLE, NORTHWEST ALONG BALTIMORE AND OHIO RAILROAD.

Connellsville, Main street, between Baltimore and Ohio Railroad and river, on top stone of south end of pier of wagon bridge over Youghiogheny River; aluminum tablet stamped "885 PITTSBURG"	884.686
Bradford, in front of station; top of rail	859.4
Dawson, in face of entrance to First National Bank; aluminum tablet stamped "851 PITTSBURG"	851.280

[a] This bench mark was determined by levels extended from the Accident quadrangle.

	Feet.
Layton, 600 feet south of station, at north end of Fayette brick works, in stone on north side of railroad arch culvert; aluminum tablet stamped "806 PITTSBURG"	806.168
Layton, in front of station; top of rail	806
Jacobs Creek, 1,200 feet south of station, on southwest corner of railroad bridge over Jacobs Creek, south abutment; aluminum tablet stamped "782 PITTSBURG"	783.472
Jacobs Creek, in front of station; top of rail	781.7
Smithton, in front of station; top of rail	781.7

BROADFORD, NORTHEAST ALONG BALTIMORE AND OHIO RAILROAD TO MOUNT PLEASANT, THENCE NORTHWEST ALONG HIGHWAY TO HUNKERS, THENCE WEST TO WEST NEWTON.

Summit Mines, in front of station; top of rail	1,224.4
Scottdale, H. C. Frick Coal Company's building, in second stone below water table, at left side of entrance; aluminum tablet stamped "1040 PITTSBURG"	1,039.561
Hammondville, in front of station; top of rail	1,039.2
Mount Pleasant, in front of station; top of rail	1,071.3
Mount Pleasant, left side at entrance to Farmers and Merchants' National Bank, on foundation stone; aluminum tablet stamped "1222 PITTSBURG"	1,222.470
Tarrs, in front of station; top of rail	1,088
Ruffsdale, in front of station; top of rail	1,042.4
Hunkers, 150 feet south of station, west end of south abutment of railroad bridge, on coping stone; bronze tablet stamped "939 PITTSBURG"	939.24
Mendon, east end of, northwest corner of brick house owned by F. F. Grove, in second stone from top of foundation; bronze tablet stamped "1104 PITTSBURG"	1,104.204

BROWNSVILLE QUADRANGLE.

WEST NEWTON, WEST ALONG HIGHWAY, TO BAIRD FLAG STATION.

West Newton, wagon bridge over Youghiogheny River, north side of east end of wing wall; aluminum tablet stamped "771 PITTSBURG"	770.742
West Newton, in front of station; top of rail	767.2
Gambles (formerly Gambles post-office), west side of front entrance to James Torren's brick house, on stone in retaining wall; bronze tablet stamped "1134 PITTSBURG"	1,133.882

WEST BROWNSVILLE, WEST-NORTHWEST ALONG HIGHWAY TO BEALLSVILLE.

Centerville (East Bethlehem post-office), 35 feet east of H. L. Smith's store, 30 feet east of center of street, Mrs. Deaves's residence, in northwest corner of retaining wall; bronze tablet stamped "1178 PITTSBURG"	1,177.821

ALLEGHENY, ARMSTRONG, BEAVER, BUTLER, WASHINGTON, AND WESTMORELAND COUNTIES.

CARNEGIE, FREEPORT, GREENSBURG, McKEESPORT, SEWICKLEY, AND SHARPSBURG QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, the elevation of which is now accepted as 738.384 feet above mean sea level. Precise-level lines of the Corps of Engineers, U. S. Army, of the Baltimore and Ohio Railroad, of the Pennsylvania Railroad, and of the United States Geological Survey traverse this area. These, corrected in accordance with the latest adjustment, form the initial control for the primary levelings. For other elevations in this locality refer to list under "Precise leveling."

The leveling was done mostly in 1903 under the direction of Mr. Frank Sutton, topographer, by C. W. Marvin, levelman, on Greensburg and part of Freeport quadrangles, and the remainder by Mr. J. H. Wetzel, levelman. Five of the bench marks on Sewickley quadrangle were established in 1905 under Mr. A. C. Roberts, topographer, by Mr. B. J. Green, levelman. The standard bench marks are stamped with the letters "PITTS" in addition to the figures of elevation.

CARNEGIE QUADRANGLE.

SMITHFIELD STREET BRIDGE, PITTSBURG, NORTHWEST TO M'KEES ROCKS, THENCE SOUTHWEST. ALONG PITTSBURG, CHARTIERS AND YOUGHIOGHENY RAILWAY AND HIGHWAY, TO CARNEGIE, THENCE ALONG PENNSYLVANIA RAILROAD TO WASHINGTON.

	Feet.
Pittsburg (south side), south end of Smithfield Street Bridge, in north face of abutment facing Pittsburg and Lake Erie Railroad, 17 feet east of west side of abutment, 9 courses of stone from top; seat cut, marked "U.S.B.M."	726.730
Smithfield Street Bridge, 1 mile west of, on signal foundation	726.84
McKees Rocks, Pittsburg and Lake Erie Bridge over mouth of Chartiers Creek, on bridge seat, north end of west abutment; aluminum tablet stamped "720 PITTSBURG"	719.480
Scully, in front of station; top of rail	747.4
McKees Rocks, 3.2 miles south of, on northeast abutment of railway bridge (railroad bench mark)	745.78
Pike, road crossing at station; top of rail	777
Thornburg, in front of station; top of rail	774
McKees Rocks, 5.2 miles south of, small bridge over Lewis Run, on coping stone at southeast corner; chiseled square	763.53
Lockton, on southwest wing wall of railroad bridge over Chartiers Creek, on coping stone; chiseled square	766.18
Carnegie, in front of station; top of rail	768.6
Carnegie, iron wagon bridge spanning Chartiers Creek at Main avenue, south end of southeast wing wall; aluminum tablet stamped "773 PITTSBURG"	772.836
Glenn station, in front of; top of south rail	802.9
Heidelburg, small arch bridge at station, on coping stone; railroad bench mark	791.97
Woodville, in front of station; top of rail	803.2
Bridgeville, Bridge No. 5 spanning Chartiers Creek, northeast wing wall of east abutment; railroad bench mark	801.32
Marshalsea, in front of; top of rail	851.3
Boyce, 3 miles south of, Bridge No. 9 spanning Chartiers Creek, on west end of north abutment; aluminum tablet stamped "857 PITTS"	856.205
Hill, road crossing at station; top of west rail	868.8
Vaneman, in front of station; top of west rail	922.9
Vaneman, Bridge No. 13, on west wing wall of north abutment; railroad bench mark	928.60
Canonsburg, iron road bridge over Chartiers Creek, Jefferson avenue, in east end of north abutment; aluminum tablet stamped "931 PITTS"	930.659

CARNEGIE, WEST ALONG PANHANDLE RAILROAD, TO M'DONALD.

Carnegie, 1.2 miles west of, Bridge No. 13; railroad bench mark	798.88
Rennerdale, in front of station; top of rail	855.5
Greggs, 600 feet west of, Bridge No. 19, on northeast coping stone; aluminum tablet stamped "893 PITTS"	892.402
Oakdale, road crossing at station; top of rail	905.9
McDonald, northeast wing wall of McDonald street iron bridge; aluminum tablet stamped "980 PITTS"	979.631

M'KEESPORT QUADRANGLE.

FINLEYVILLE, NORTHEAST ALONG BALTIMORE AND OHIO RAILROAD, TO THOMPSON FLAG STATION.

Cochran Mills, southwest coping stone of stone-arch bridge; aluminum tablet stamped "884 PITTS"	882.546
Cochran Mills, road crossing at station; top of rail	894.3
Wallace, road crossing at station; top of rail	903.8
Bruce, 0.5 mile north of Bridge No. 90, on bridge seat; railroad bench mark	1,002.16
Willoch, iron highway bridge at station, on southeast wing wall; aluminum tablet stamped "926 PITTS"	925.060
Hayes, near station, south side of land pier of Baltimore and Ohio Railroad overhead bridge; railroad bench mark	760.49

HULTON, SOUTH ALONG PITTSBURG, BUFFALO AND LAKE ERIE RAILROAD, TO BESSEMER.

North Bessemer, 1 mile south of, north end of tunnel, on west side, third stone from bottom; aluminum tablet stamped "1023 PITTS"	1,022.321
Bessemer Bridge; bronze tablet stamped "759 PITTS"	759.492

SHARPSBURG QUADRANGLE.

	Feet.
CHESWICK, NORTH ALONG HIGHWAY AND PITTSBURG, BESSEMER AND LAKE ERIE RAILROAD, TO BARTLEY STATION.	
Grey's mill, iron bridge over wagon road, southwest bridge seat; aluminum tablet stamped "975 PITTS"	974.406
Bartley, south side of door entrance to store of T. G. Kennedy, in foundation wall; aluminum tablet stamped "1171 PITTS"	1,171.013
BARTLEY STATION, WEST ALONG HIGHWAY, TO VALENCIA. (DOUBLE LINE.)	
Glade Mills, brick residence of J. W. Starr, in northeast foundation stone; aluminum tablet stamped "1087 PITTS"	1,086.348
VALENCIA, SOUTH ALONG PITTSBURG AND WESTERN (BALTIMORE AND OHIO) RAILROAD, TO SHARPSBURG.	
Gibsonia, 1,200 feet south of station, east end of south abutment of small Bridge No. 336; aluminum tablet stamped "1031 PITTS"	1,030.880
Wildwood, 1 mile north of, northeast bridge seat of small wooden bridge; copper bolt	959.124
Wildwood, southwest bridge seat of Bridge No. 329; copper bolt (railroad bench mark)	915.31
Bryant, 1 mile west of, northwest bridge seat of Bridge No. 327; copper bolt (railroad bench mark)	902.64
Bryant, 1.5 miles south of station, Pittsburg and Western Bridge No. 323 over Pine Creek, southeast bridge seat; aluminum tablet stamped "853 PITTS"	853.125
Elfinwild, 300 feet west of station, southeast bridge seat; copper bolt (railroad bench mark)	833.29
Glenshaw, 300 feet north of, northeast bridge seat; copper bolt (railroad bench mark)	789.12
Pine Creek, 0.1 mile east of station, railroad bridge spanning Pine Creek, northwest abutment; copper bolt (railroad bench mark)	733.04
SEWICKLEY QUADRANGLE.	
VALENCIA, NORTH ALONG PITTSBURG AND WESTERN RAILROAD, TO MARS, THENCE WEST ALONG HIGHWAY, VIA BRUSH VALLEY, TO FREEDOM.	
Downieville, 1,400 feet north of station, on northwest bridge seat of small culvert bridge; bronze tablet stamped "1036 PITTS"	1,035.341
Brush Creek, 3 miles east of, south side of road, northwest corner of J. F. Martin's barn, in foundation; bronze tablet stamped "1245 PITTS"	1,245.234
Brush Creek, stone-arch bridge over Brush Creek, in southwest coping stone; bronze tablet stamped "1066 PITTS"	1,066.096
Lovi, southeast corner of store and post-office, in foundation wall; bronze tablet stamped "1138 PITTS"	1,137.771
Conway, 2 miles east of, iron highway bridge over Crows Run near Parks's store, on north end of southwest wing wall; aluminum tablet stamped "802 PITTS"	801.792
BRYANT, WEST ALONG HIGHWAY, VIA PERRYSVILLE, TO DIXMONT.	
Emsworth, 3.7 miles east of, iron bridge over Lowrie Run, on northeast wing wall; bronze tablet stamped "881 PITTS"	880.918
Dixmont, northeast corner of gas house; east sill of window	719.46
Dixmont, 75 feet east of entrance to hospital, in coping stone of retaining wall; bronze tablet stamped "727 PITTS"	726.930
AT ECONOMY AND BEN AVON. (SET FROM PITTSBURG, FORT WAYNE AND CHICAGO RAILROAD LEVELS CORRECTED.)	
Economy, 2,000 feet north of; northeast corner of north coping of Bridge No. 15	711.55
Economy, 2,000 feet north of, on second step from top of Bridge No. 15, on northwest wing wall; bronze tablet stamped "710 PITTS"	710.119
Ben Avon, northwest corner Pittsburg, Fort Wayne and Chicago Railway station, in foundation wall; bronze tablet stamped "728 PITTS" (1.96 feet higher than railroad bench mark on Bridge No. 6)	727.871
AT STOOPS FERRY. (SET FROM ARMY ENGINEERS' PRECISE-LEVEL LINE.)	
Stoops Ferry station (opposite Sewickley), northwest abutment wall of Pittsburg and Lake Erie Railroad bridge over Narrows Run, on top of third course of stone below top; bronze tablet stamped "721 PITTS"	721.266

GREENSBURG QUADRANGLE.

MOSS SIDE (OLD LINE PENNSYLVANIA RAILROAD), ALONG RAILROAD, VIA STEWART STATION AND MURRAYSVILLE, TO EXPORT, THENCE ALONG HIGHWAY, VIA DELMONT AND HARVEYS FIVE POINTS, TO GREENSBURG.

	Feet.
Moss Side, at station, near northwest corner of fence of dwelling; stone monument (Pennsylvania Railroad bench mark)	763.111
Stewarts, 600 feet west of station, in capstone north end stone bridge over creek, 50 feet east of west end; copper bolt (Pennsylvania Railroad bench mark No. 80)	782.621
Saunders Junction, 0.84 mile west of, bridge over Turtle Creek, on southeast corner stone of abutment, west end of bridge; tip cut	817.91
Murraysville, 800 feet west of station, west end of bridge over Turtle Creek, south end of stone abutment, in top of next to top step; bronze tablet stamped "897 PITTS"	897.143
Export, 0.3 mile west of station, power house at Elizabeth coal tipple, on southwest corner of water table; tip cut	973.56
Export, 0.1 mile east of, in south end of coal building at tipple of Westmoreland Coal Company, 2.5 feet west of door, foundation of boiler room; aluminum tablet stamped "983 PITTS"	982.220
Delmont, at southeast corner of National Bank building, on northwest corner of cross streets, west side of corner post; top of watet table	1,265.82
Harveys Five Points, frame house of A. B. Huff, 5 feet west of southeast corner of foundation; bronze tablet stamped "1327 PITTS"	1,327.279
Millers schoolhouse, on foundation, 10 feet east of southwest corner; square cut	1,289.67
Greensburg, east end of tunnel; Pennsylvania Railroad bench mark	1,085.875
Greensburg, 350 feet south of station, in water table of Monaham Hotel, 1 foot south of northwest corner; aluminum tablet stamped "1079 PITTS"	1,078.296

AT JEANNETTE AND IRWIN.

Grapeville, 300 feet east of station, brick house, base course in bay window; Pennsylvania Railroad bench mark No. 71	1,059.561
Jeannette, 120 feet east of station, south of track and west of overhead bridge, in angle of stone wall; aluminum tablet stamped "1040 PITTS"	1,039.87
Irwin, Youghiogheny Railroad bridge, west end of north back wall; Pennsylvania Railroad bench mark	879.107
Irwin, south side of station, in center of third capstone east of west end of west wing wall of highway bridge over street; aluminum tablet stamped "888 PITTS"	888.025

FREEPORT QUADRANGLE.

EDGECLIFF, ALONG HIGHWAY EAST, VIA M'LAUGHLINSVILLE (MERWIN), TO PAULTON.

Edgecliff, 400 feet south of station, in north abutment, east side of bridge over creek; bronze tablet stamped "764 PITTS 1899"	763.468
Edgecliff, 0.93 mile east of, in southeast corner of foundation of barn of F. E. Blair; point in projection stone	806.79
Merwin, in northeast corner of foundation of house of Philip Love; aluminum tablet stamped "1244 PITTS 1903"	1,244.127
Paulton, county bridge, in southwest wing wall; copper bolt	809.532
Paulton, county bridge, in northeast corner of west abutment; aluminum tablet stamped "810 PITTS 1903"	809.364

LEECHBURG, NORTHEAST ALONG HIGHWAY (KITTANNING ROAD), TO ROSSTON.

Leechburg, wagon bridge spanning Kiskiminitas Creek, on northeast corner stone; bronze tablet stamped "789 PITTS"	788.625
Neale post-office, 1 mile south of, 50 feet south of coal drift on right side of road, in sewer stone; aluminum tablet stamped "984 PITTS"	984.044

LAWRENCE AND MERCER COUNTIES.

MERCER, NESHANNOCK, AND YOUNGSTOWN (OHIO-PA.) QUADRANGLES.

The elevations in the following list are based upon the 1903 adjustment datum, the connection being obtained through leveling on the Newcastle quadrangle from Enon and Homewood. The leveling was done in 1905 under the direction of Mr. A. C. Roberts, topographer, by Mr. J. H. Wetzel, levelman. The standard bench marks are stamped "ADJ 1903" in addition to the figures of elevation.

NESHANNOCK QUADRANGLE.

	Feet.
Edenburg,[a] 2 miles west of, on southeast pier of switch tower of Pittsburg and Lake Erie Railroad, and 2,000 feet west of Carbon brick works; bronze tablet stamped "801 ADJ 1903"	801.135

NEWCASTLE, NORTH ALONG PENNSYLVANIA RAILROAD, TO NEW WILMINGTON, THENCE NORTHWEST ALONG SHARPSVILLE RAILROAD, TO SHARPSVILLE.

Eastbrook, on southeast bridge seat of highway bridge; bronze tablet stamped "904 ADJ 1903"	904.117
Wilmington Junction, 1,200 feet northeast of, on northwest bridge seat of railroad bridge over Neshannock River; bronze tablet stamped "931 ADJ 1903"	931.253
New Wilmington, 1,800 feet east of, on northwest wing wall of iron highway bridge over Neshannock River; bronze tablet stamped "957 ADJ 1903"	956.950
New Wilmington, street crossing at station; top of rail	970.8
Lyle, road crossing at station; top of rail	1,010.9
Carbon, road crossing at station; top of rail	1,040.7
Bethel, 700 feet east of, northwest wing wall of iron highway bridge; bronze tablet stamped "1071 ADJ 1903"	1,070.570
Neshannock, road crossing at station; top of rail	1,101.8
Oakland, road crossing at station; top of rail	1,129.6
Hermitage, road crossing at station; top of rail	1,096.4
Hermitage, on stone door step at entrance to school; aluminum tablet stamped "1099 ADJ 1903"	1,099.130

NEW WILMINGTON, NORTHEAST, ALONG HIGHWAY, TO MERCER, THENCE WEST TO HERMITAGE.

Mercer, 3 miles southwest of, in northeast corner of Shannon's residence; aluminum tablet stamped "1316 ADJ 1903"	1,315.837
Charlestown (Hill post-office), primary traverse station No. 1, on south side of street, at intersection of streets; aluminum tablet stamped "1263 ADJ 1903"	1,262.696

NEWCASTLE, NORTHWEST ALONG PENNSYLVANIA RAILROAD, TO WHEATLAND.

Newcastle, north wing wall of west abutment of Washington Street Bridge; aluminum tablet stamped "808 PITTSBURG 1901"	807.712
Newcastle, southeast abutment of small culvert near yard limit; railroad bench mark	805.77
Newcastle, 4 miles north of, iron wagon bridge known as Harber Bridge, northwest corner stone of bridge seat; bronze tablet stamped "807 ADJ 1903"	806.733
Nashua Junction, on southwest abutment of small railroad culvert; bronze tablet stamped "810 ADJ 1903"	809.655
Pulaski, on southwest abutment of iron highway bridge; bronze tablet stamped "828 ADJ 1903"	827.678
West Middlesex, in northwest wing wall of iron highway bridge; bronze tablet stamped "841 ADJ 1903"	841.080

YOUNGSTOWN QUADRANGLE.

WHEATLAND, NORTH ALONG PENNSYLVANIA RAILROAD, TO SHARPSVILLE.

Wheatland, 0.25 mile west of, on southeast bridge seat of iron highway bridge over Shenango River; bronze tablet stamped "842 ADJ 1903"	841.747
South Sharon, in front of station; top of rail	852.4
Sharon, near high school building, on northeast abutment of iron highway bridge over Shenango River; bronze tablet stamped "856 ADJ 1903"	855.921

MERCER QUADRANGLE.

AT MERCER (BY CIRCUIT NEW WILMINGTON TO HERMITAGE).

Mercer, on northeast corner of court-house steps; aluminum tablet stamped "1277 ADJ 1903"	1,276.930

[a] Bench mark set from Baltimore and Ohio Railroad bench mark No. 368 (subtracting 0.091 foot from railroad company's elevation).

BEAVER AND LAWRENCE COUNTIES.

BEAVER AND NEWCASTLE QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, the elevation of which is now accepted as 738.384 feet above mean sea level. The initial points upon which this work depends are various bench marks of precise-level lines run by the Pennsylvania Railroad Company and the Corps of Engineers, U. S. Army. The elevations accepted for these are the result of the latest adjustment.

The leveling was done in 1901 under the direction of Mr. Frank Sutton, topographer, by Mr. Ira M. Flocker, levelman, except that at Freedom, which was done in 1905 under Mr. A. C. Roberts, topographer, by Mr. B. J. Green, levelman. The standard bench marks are stamped with the letters "PITTSBURG" in addition to the figures of elevation.

NEWCASTLE QUADRANGLE.

NEW GALILEE, SOUTHWEST ALONG RAILROAD, TO DARLINGTON AND RETURN.

	Feet.
New Galilee, northeast corner of east back wall of Bridge No. 42; bench mark No. 2116 (Pittsburg, Fort Wayne and Chicago Railroad precise levels)	959.71
New Galilee, 1 mile southwest of, Pittsburg, Lisbon and Western Railroad bridge over Little Beaver; northeast corner of south abutment	931.37
Darlington, at intersection of Market and Second streets, in front of Darlington Hotel, on top of stone; bronze tablet stamped "912.5 PITTSBURG 1901"	912.222

AT BEAVER FALLS.

Beaver Falls; bench mark No. 1596 (Pittsburg, Fort Wayne and Chicago Railroad precise levels)	789.366
Beaver Falls, Pittsburg, Fort Wayne and Chicago Railroad bridge over Eleventh street, west end of south abutment, in coping stone; aluminum tablet stamped "789.8 PITTSBURG 1901"	789.479

ENON, NORTH ALONG HIGHWAY, VIA MOUNT JACKSON, TO NEWCASTLE, THENCE SOUTHEAST ALONG PITTSBURG AND LAKE ERIE RAILROAD VIA WAMPUM, TO HOMEWOOD.

Enon; bench mark No. 2385, Pittsburg, Fort Wayne and Chicago Railroad precise levels	995.635
Enon, 400 feet south of railroad track on Main street, in top of county line stone; bronze tablet stamped "1013.4 PITTSBURG 1901"	1,013.187
Mount Jackson, at postoffice, 60 feet north of street intersection, in side of square stone hitching post; bronze tablet stamped "1165 PITTSBURG"	1,164.787
Mahoningtown, highway bridge over the Mahoning, on wing wall of south abutment (nearest Pittsburg, Youngstown and Ashtabula Railroad track); seat cut in corner of	786.0
Mahoningtown, in front of station, Pittsburg and Lake Erie southbound track; north rail	779.6
Newcastle, in front of station; top of rail	806
Wampum, in front of station; top of rail	803.0
Wampum, 500 feet south of station, northeast corner of arch bridge over Wampum Run, on coping stone; aluminum tablet stamped "804.7 PITTSBURG"	804.438
Homewood; bench mark No. 1840 (Pittsburg, Fort Wayne and Chicago Railroad precise levels)	949.972

BEAVER QUADRANGLE.

BEAVER, WEST ALONG HIGHWAYS, VIA DAWSON TRIANGULATION STATION, TO BLACK HAWK, THENCE SOUTH, VIA FAIRVIEW, TO INDUSTRY.

Beaver, Pittsburg and Lake Erie Railroad bridge over Ohio River, land pier on right shore of river, 3 inches below top of nineteenth course of stone from top of pier and 3 feet east of west side of pier; seat on southwest end of land pier marked thus: "U. S. B. M." (United States Engineers' bench mark "25 C")	686.444
West Bridgewater, Cleveland and Pittsburg Railroad, west-bound track at station; top of north rail	708.7
Beaver, in foundation stone east of entrance to court-house; aluminum tablet stamped "798 PITTSBURG"	797.654

	Feet.
Black Hawk, at crossroads, at corner of barn, on large rock; aluminum tablet stamped "1169.3 PITTSBURG"	1,169.013
Industry, Cleveland and Pittsburg Railroad Bridge No. 117 over State road, south end of west abutment, in end of second stone from top; bronze tablet stamped "696 PITTSBURG"	696.060
Industry, 600 feet above landing, 400 feet above Safe Harbor ferry landing, on left shore of river, on large rock under bank; seat cut (United States Engineers' bench mark "32 B")	673.344

INDUSTRY, SOUTH ALONG HIGHWAYS, VIA HOOKSTOWN, TO KENDALL, THENCE EAST TO PATTON'S BRIDGE, THENCE NORTHEAST, VIA NEW SHEFFIELD, TO WOODLAWN.

Hookstown, stone bridge on Washington road over small stream, on southwest corner (corner by the Robertson House); aluminum tablet stamped "968.6 PITTSBURG"	968.220
Kendall, 1 mile east of (about 5 miles southeast of Hookstown), on Big Traverse Creek, red brick house of James Buchanan, in foundation stone; aluminum tablet stamped "1069.7 PITTSBURG"	1,069.360
Clinton, 4 miles northwest of, 6 miles northeast of Frankfort Springs, in south end of west abutment of Patton's bridge over Raccoon Creek; aluminum tablet stamped "848"	847.022
New Sheffield, in northeast corner of Johnston's mill; aluminum tablet stamped "943.7 PITTSBURG"	943.666

AT FREEDOM (SET FROM PITTSBURG, FORT WAYNE AND CHICAGO RAILROAD LEVELS, CORRECTED).

Freedom, northwest corner east bridge seat of Bridge No. 204; railroad bench mark	703.445
Freedom, at northeast corner of railroad bridge over Eighth street, on wing wall; aluminum tablet stamped "701 PITTS"	701.049

ALLEGHENY, BEAVER, AND WASHINGTON COUNTIES.

BURGETTSTOWN, CLAYSVILLE, AND STEUBENVILLE QRADRANGLES.

The elevations in the following list are based upon work in adjoining quadrangles of West Virginia and Pennsylvania, corrected in accordance with the 1903 adjustment of the precise level net.

The leveling was done mostly in 1904 under direction of Mr. W. T. Griswold, topographer, but a portion of the work on Claysville quadrangle was done in 1905 under Mr. M. J. Munn, assistant topographer, all by Mr. B. J. Green, levelman. Standard bench marks set in 1904 and 1905 in this area are stamped with the legend "ADJ 1903" and "ADJ" respectively, while those set previously on the Claysville and Steubenville quadrangles are stamped respectively "PITTS" or "STBNVL" in addition to figures of elevation.

BURGETTSTOWN QUADRANGLE.

M'DONALD, ALONG PENNSYLVANIA RAILROAD,[a] TO HANLIN.

	Feet.
Primrose, 500 feet west of station, on south end of east abutment of Bridge No. 24; chiseled square (railroad bench mark)	1,024.10
Midway, on north end of east abutment of Bridge No. 25 over county road at west end of station; aluminum tablet stamped "1111 ADJ 1903"	1,110.666
Bulger, 0.3 mile west of, on catch-basin at northeast end of tunnel; chiseled square	1,156.64
Burgettstown, on south foundation wall of Burgettstown National Bank building; aluminum tablet stamped "1000 ADJ 1903"	999.180
Hanlin, on coping at northeast corner of Bridge No. 32 over county road and 200 feet east of station; bronze tablet stamped "942 ADJ 1903"	942.181

BURGETTSTOWN, NORTH ALONG HIGHWAY, VIA MURDOCKSVILLE, TO PATTON'S BRIDGE.

Burgettstown, 2.6 miles northeast of, in south end of east abutment of iron bridge over Raccoon Creek, at forks to west; chiseled square	946.63
Bavington, 0.2 mile north of, on east end of south abutment of iron bridge over Raccoon Creek; aluminum tablet stamped "921 ADJ 1903"	920.874
Murdocksville, on north end of east abutment of iron bridge over Raccoon Creek; bronze tablet stamped "877 ADJ 1903"	877.083
Murdocksville, 2.5 miles north of, on south end of west abutment of iron bridge over Big Traverse Creek, chiseled square	845.47

[a] The adjustment of railroad levels between Pittsburg and Steubenville involves the Geological Survey leveling from Pittsburg to Burgettstown.

MURDOCKSVILLE, EAST ALONG HIGHWAY, TO CLINTON, THENCE NORTHWEST TO PATTON'S BRIDGE.

	Feet.
Clinton, on foundation wall at southeast corner of J. E. McCullough's store and post-office; bronze tablet stamped "1234 ADJ 1903"	1,233.882

MURDOCKSVILLE, WEST ALONG HIGHWAY, TO COMETTSBURG.

Frankfort, on north foundation wall of brick dwelling of Andrew Vance's heirs, on west side of street at south end of town; aluminum tablet stamped "1186 ADJ 1903"	1,185.604
Frankfort, 2.3 miles west of; spot on abutment at northwest corner of covered bridge at crossroads south of pump station	987.074
Comettsburg, in foundation wall at southeast corner of Freshwater's house; bronze tablet stamped "1150 STBNVL"	1,149.920

FRANKFORT, SOUTH-SOUTHEAST ALONG HIGHWAY, TO BURGETTSTOWN.

Florence, on east foundation wall of O. K. Simpson's dwelling on south side of street opposite road to Frankfort; aluminum tablet stamped "1282 ADJ 1903"	1,282.534

BURGETTSTOWN, SOUTH ALONG HIGHWAY, TO NEAR CROSS CREEK VILLAGE, THENCE SOUTHEAST, VIA HICKORY, TO CANONSBURG.

Burgettstown, 3.5 miles south of, 1.5 miles east of Cross Creek village, in wing wall at northeast corner of covered bridge over Raccoon Creek; aluminum tablet stamped "1037 ADJ 1903"	1,036.776
Hickory, on south wall at southwest corner of J. M. Griffith's dwelling; aluminum tablet stamped "1303 ADJ 1903"	1,302.800
Westland, on east end of south abutment of railroad bridge, 300 feet north of Pittsburg Coal Company's Midland mine No. 3 tipple; bronze tablet stamped "1024 ADJ 1903"	1,024.795

HICKORY, WEST ALONG WABASH RAILROAD, TO NEAR INDEPENDENCE.

Hickory, 2.2 miles southwest of, on east end of north abutment of sewer 100 feet west of tunnel; chiseled square	1,170.584
Woodrow, 0.6 mile east of, in south end of west abutment of bridge over county road; bronze tablet stamped "1134 ADJ 1903"	1,134.622
Woodrow, 1.8 miles west of, on bridge seat of bridge over county road, just south of second covered bridge at crossroads; railroad bench mark	1,046.98
Woodrow, 3.8 miles west of, 2 miles north of West Middleton, on bridge seat at southwest corner of bridge over county road; railroad bench mark	977.46
Patterson Mills, 1 mile south of, on south end of west abutment of large iron bridge over Cross Creek; railroad bench mark	912.966
Patterson Mills, 1 mile south of, on north end of east abutment of railroad bridge over Cross Creek, just west of road crossing; bronze tablet stamped "905 ADJ 1903"	904.828
Twin tunnels, second bridge west of; railroad bench mark on south end of west abutment	826.732

STEUBENVILLE QUADRANGLE.

Independence, 2.5 miles northwest of, 0.1 mile east of State line in southeast corner of county bridge over Cross Creek; aluminum tablet stamped "784 STBNVL"	784.024

CLAYSVILLE QUADRANGLE.

VALLEY GROVE, W. VA., NORTHWEST ALONG BALTIMORE AND OHIO RAILROAD IN PENNSYLVANIA, VIA COON ISLAND AND CROTHERS, TO WASHINGTON.

Valley Grove, 3 miles northeast of, State line (W. Va.–Pa.) monument, at the base of northeast side of Baltimore and Ohio Railroad Bridge No. 170	1,156.280
Coon Island (Vienna post-office), in front of station, railroad Bridge No. 166, in northeast capstone; bronze tablet stamped "1000 PITTS"	1,000.192
Claysville, public schoolhouse, at southeast corner, in foundation wall; aluminum tablet stamped "1127 ADJ 1903"	1,126.972
Tunnel No. 4, at east end of; cut on ledge of rock	1,126.79
Crothers, 0.5 mile southeast of, railroad Bridge No. 160, Pittsburg division, east abutment, set in capstone; bronze tablet stamped "1011 PITTS"	1,010.798
Finney, 120 feet north of station, southwest corner of E. T. Boone's dwelling, in foundation wall; bronze tablet stamped "1190 ADJ 1903"	1,189.809

PRYOR, SOUTH ALONG HIGHWAY, VIA WEST MIDDLETOWN AND TAYLORSTOWN, TO CROTHERS.

	Feet.
West Middleton, in foundation wall at northeast corner of M. M. Hemphill's brick dwelling; bronze tablet stamped "1332 ADJ 1903"	1,332.105
West Middletown, 3.7 miles south of, on large rock on east side of road, 360 feet south of covered bridge over Brush Run; bronze tablet stamped "903 ADJ 1903." (On a double-spur line 0.6 mile)	903.410
Buffalo, 2.7 miles southwest of, on abutment at southwest corner of covered bridge over Brush Run on Buffalo and Taylortown road; bronze tablet stamped "1028 ADJ 1903"	1,027.910
Buffalo, in foundation wall at southeast corner of H. W. Leeche's dwelling, on west side of street opposite post-office and store; bronze tablet stamped "1307 ADJ 1903." (On a double-spur line from preceding)	1,307.752
Taylorstown, 1.3 miles north of, east of large steel oil tank at northwest corner of large iron bridge over Buffalo Creek, on bridge seat; bronze tablet stamped "975 ADJ 1903"	975.814
Taylorstown, 0.6 mile northwest of, east of three corners on abutment at extreme northwest corner of large iron bridge over Buffalo Creek; chiseled square	981.73

COON ISLAND (VIENNA), NORTH ALONG PUBLIC ROAD, TO DUTCH FORK SCHOOLHOUSE AND RETURN.

Coon Island, 1.1 miles northwest of, on abutment at southwest corner of iron bridge over Dutch Fork, just south of forks to west; chiseled square	978.02
Budaville, 0.3 mile southwest of, north side of road fork to east from schoolhouse situated west of main road, on northwest corner of iron bridge over Dutch Fork; bronze tablet stamped "917 ADJ 1903"	917.3

CLAYSVILLE, SOUTH ALONG HIGHWAY, TO BURDETTE.

Fargo, 0.5 mile north of, on east side of road just north of point opposite road fork to west, on culvert abutment; bronze tablet stamped "1466 ADJ"	1,465.680
East Finley, 2 miles north of, west of three corners, on west abutment of covered bridge over Templeton Run; bronze tablet stamped "1092 ADJ"	1,092.307
Good Intent, 2.8 miles southeast of, in face of sandstone ledge on west of road, west side of Templeton Run; bronze tablet stamped "1037 ADJ"	1,037.377

FROM POINT 4.5 MILES SOUTH OF FARGO, WEST TO GOOD INTENT, AND RETURN.

Good Intent, southeast corner of foundation wall of school building; bronze tablet stamped "1052 ADJ"	1,052.228

ENO, NORTHEAST ALONG HIGHWAY, TO PROSPERITY, THENCE EAST TO AMITY.

Old Concord, on step of entrance to church; bronze tablet stamped "1118 ADJ"	1,117.920
Prosperity, 1 mile southeast of, 0.1 mile south of three corners, on abutment at northeast corner of covered bridge; bronze tablet stamped "993 ADJ"	992.984

WEST WASHINGTON, SOUTH ALONG HIGHWAY TO PROSPERITY.

Lagonda, on east wall of brick schoolhouse at crossroads; bronze tablet stamped "1076 ADJ 1903"	1,075.986
Van Buren, in foundation wall at southeast corner of Bethel Church; bronze tablet stamped "1325 ADJ 1903"	1,325.610

GREENE AND WASHINGTON COUNTIES.

AMITY, BLACKSVILLE, ROGERSVILLE, AND WAYNESBURG QUADRANGLES.

The elevations in the following list are based upon an aluminum tablet in the foundation of the Seventh Avenue Hotel, Pittsburg, stamped "738 PITTSBURG 1899," the elevation of which is now accepted as 738.384 feet above mean sea level. They agree in datum with the latest adjustment of precise leveling.

The leveling was done as follows: On the Waynesburg quadrangle, in 1900, under the direction of Mr. Frank Sutton, topographer, by Mr. J. H. Wetzel, levelman; on the Blacksville quadrangle, in 1901, under Mr. A. H. Bumstead, topographer, by Mr. M. P. Page, levelman; on the Rogersville quadrangle, mostly in 1902, under Mr. R. D. Cummin, topographer, by Mr. Charles Hartman, jr., levelman; and on the Amity quadrangle, partly in 1901, under Mr. A. H. Bumstead, topographer, by Messrs. M. P. Page and H. Wood, levelmen; partly

in 1902, under Mr. R. D. Cummin, topographer, by Mr. Charles Hartman, jr., levelman; partly in 1903, under Mr. Sutton, by Mr. Wetzel, and partly in 1904, under Mr. W. T. Griswold, topographer, by Mr. J. B. Green, levelman. The final work on this and Rogersville quadrangle was that extended from Claysville quadrangle, in 1905, under Mr. M. J. Munn, assistant topographer, by Mr. Green. The standard bench marks, except that at Mount Morris, are stamped "PITTS" or "PITTSBURG" in addition to figures of elevation, which, being taken from unadjusted field values, are in many cases incorrect.

WAYNESBURG QUADRANGLE.

CARMICHAELS, WEST ALONG HIGHWAY, TO KHEDIVE, THENCE NORTH TO CLARKSVILLE, THENCE WEST TO RUFF CREEK, THENCE SOUTH TO WAYNESBURG, THENCE SOUTHEAST TO POINT MARION.

	Feet.
Khedive, in west end of residence of Mrs. Sarah Yoder, on foundation stone under bay window; aluminum tablet stamped "1013 PITTSBURG"	1,013.255
Clarksville, 1 mile south of, covered bridge over Tenmile Creek, northwest wing wall, on coping stone (next to bridge); bronze tablet stamped "814 PITTSBURG"	814.167
Ruff Creek, northeast corner of wooden dwelling house of John Breston, in upper foundation stone; bronze tablet stamped "999 PITTSBURG"	997.697
Waynesburg, northwest corner of stone court-house veranda; bronze tablet stamped "1035 PITTSBURG"	1,034.446
Newton, on northeast wing wall of iron bridge, 2 coping stones from bridge; bronze tablet stamped "1010 PITTSBURG"	1,009.525
Davistown, in ledge of rocks at end of middle (wooden) bridge, northeast wing wall; bronze tablet stamped "932 PITTSBURG"	932.174
Davistown, 1.5 miles southeast of, iron bridge over Dunkard Creek, on northwest wing wall; chiseled square	871.87

WAYNESBURG, WEST ALONG PUBLIC ROADS, TO ROGERSVILLE.

Waynesburg, 3 miles west of highway bridge on Rogersville road, on southeast abutment; chiseled square	952.78

BLACKSVILLE QUADRANGLE.

CORE, W. VA., NORTHEAST ALONG HIGHWAY, TO MOUNT MORRIS.

Mount Morris, 150 feet west of mill, in northwest abutment of bridge over Robinson Run, 8 feet from north end of bridge, 10 feet from center of road; bronze tablet stamped "904 GRAFTON"	903.840

AMITY QUADRANGLE.

BEALLSVILLE, NORTHWEST ALONG PUBLIC ROADS, VIA SCENERY HILL AND VANCEVILLE, TO EIGHTYFOUR.

Beallsville 50 feet southeast of center of crossroads, Greenfield's Hotel, 30 feet west of corner of porch, in middle step; bronze tablet stamped "1137 PITTSBURG"	1,135.970
Scenery Hill, Hillsboro triangulation station, at top of; bronze tablet stamped "1467 PITTSBURG"	1,466.853
Vanceville, 1.7 miles northwest of, bridge over Pigeon Creek, 235 feet south of center of crossroads, set in north end of southwest abutment; bronze tablet stamped "1044 PITTSBURG"	1,042.454

WASHINGTON, NORTHEAST ALONG BALTIMORE AND OHIO RAILROAD, VIA EIGHTYFOUR, TO FINLEYVILLE STATION.

Washington, Cherry and Main streets, southeastern end of boundary wall of court-house, in south side; bronze tablet stamped "1156 PITTS"	1,156.064
Washington, 3.5 miles east of, Bridge No. 153, northwest corner of east abutment; chisel-mark.	1,112.434
Zediker, in front of station; top of rail	1,034.4
Eightyfour, post-office, 7 miles east of Washington, Bridge No. 140, on southwest wing wall; bronze tablet stamped "992 PITTS"	991.754
Gilkeson, north end of platform: bench mark	1,092.58
Thomas station, southeast end of platform; bench mark	1,135.60
Venetia post-office (Anderson station), northwest bridge seat of iron wagon bridge at road crossing; aluminum tablet stamped "986 PITTS"	985.072
Hackett, road crossing; top of rail	954.4

WASHINGTON, SOUTH ALONG WAYNESBURG AND WASHINGTON RAILROAD AND PUBLIC ROADS, VIA AMITY, TO RUFF CREEK.

	Feet.
Amity, post-office and store of F. F. Iams & Son, in stone doorstep, on north side of door, east side of road; aluminum tablet stamped "1204 PITTSBURG"	1,200.898

ROGERSVILLE QUADRANGLE.

ROGERSVILLE, NORTH TO NINEVEH, THENCE WEST ALONG PUBLIC ROADS, VIA TIME, ENO, AND SIMPSON STORE, TO BURDETTE.

Rogersville, highway bridge over Tenmile Creek, in capstone of southwest abutment; aluminum tablet stamped "978 PITTS"	977.337
Nineveh, entrance to Van Olive Hotel, in southeast top of foundation wall; aluminum tablet stamped "1023 PITTS"	1,022.180
Eno, on top step of entrance to church; chiseled square	997.59
Eno, 1.5 miles west of, on northwest abutment of iron bridge over Enslow Fork Wheeling Creek; chiseled square	963.20
Burdette, Braden's mill (formerly Clansen's mill), highway bridge over Enslow Fork Wheeling Creek, in capstone of southeast abutment; bronze tablet stamped "918 PITTS"	917.211

BRADEN'S MILL, SOUTH ALONG PUBLIC ROADS, VIA RYERSON STATION AND ALEPPO, TO DEEP VALLEY.

McCracken, 0.5 mile north of, near Earnests residence, on abutment of covered bridge over South Fork Dunkard Fork Wheeling Creek; chiseled square	974.93
Aleppo post-office (Bridgeport), in southwest abutment of highway bridge over South Fork Dunkard Fork Wheeling Creek; bronze tablet stamped "1060 PITTS"	1,059.588
Morford post-office, 4.4 miles south of, at forks of road leading to Bellton, New Freeport, and Aleppo, covered bridge over Wagonroad Run, on southwest abutment; chiseled square	1,004.67

BELLTON, W. VA., EAST ALONG PUBLIC ROADS, VIA DEEP VALLEY AND NEW FREEPORT, TO PINEBANK, THENCE NORTH TO ROGERSVILLE.

Deep Valley, public bridge over Pennsylvania Fork Fish Creek, on northeast abutment; chiseled square	1,015.81
New Freeport, 2 miles west of, public bridge over Laurel Run, near Methodist Church, on southeast abutment; chiseled square	1,031.17
New Freeport, bridge over Pennsylvania Fork Fish Creek, in southwest abutment; bronze tablet stamped "1062PITTS"	1,062.006
Pinebank, highway bridge over Toms Run, in southeast abutment; bronze tablet stamped "1006 PITTS"	1,005.454

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[Bulletin No. 288.]

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A RECONNAISSANCE

OF THE

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IN 1905

BY

G. C. MARTIN

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A RECONNAISSANCE OF THE MATANUSKA COAL FIELD, ALASKA, IN 1905.

By G. C. MARTIN.

INTRODUCTION.

The region described in this paper extends northeast from the upper end of Knik Arm, the northerly branch of Cook Inlet. It lies between latitudes 61° 30′ and 61° 50′ north, and longitudes 148° and 149° 30′ west. It is about 80 miles long in a northeast-southwest direction, and from 5 to 10 miles wide.

The occurrence of coal in this region was first learned from the Indians by prospectors and traders in 1894. A little exploration was done during the following year or two, but the search was chiefly for placer gold, as coal deposits in this region were then of no value because of the lack of transportation. In 1898 and 1899 the region was traversed by army exploring parties. The first of these was accompanied by W. C. Mendenhall of the United States Geological Survey, who, in his reports[a], described the region from Knik station to the headwaters of the Matanuska and northward to the Tanana. These reports outlined briefly the geology along the route traversed, and alluded to the presence of coal. The journey was, however, so hurried that Mendenhall did not see the principal coal outcrops. In 1903 the assurance of construction of the railroad from the head of Resurrection Bay to the Yukon Valley revived interest in these coal fields, and since then they have been actively prospected and steps have been taken toward securing title to coal lands. In 1904 R. W. Stone[b] compiled information in regard to this field, but made no examination of the region.

The writer, under instructions of Mr. Alfred H. Brooks, geologist in charge of the division of Alaskan mineral resources, spent about three weeks in this field in the summer of 1904, visiting the region immediately adjacent to Matanuska River from Knik Arm nearly to the mouth of Hicks Creek. The following pages contain the results[c] of this investigation, together with such other information as could be compiled.

Messrs. Frank Watson and Thomas Jeter, of Seward, George Palmer, of Knik, William Griffith, of Scranton, Pa., and many others, have extended courtesies in the field and elsewhere which have added to both the value and the pleasure of the work.

[a] Report on the region between Resurrection Bay and the Tanana River: Maps and Descriptions of Routes of Exploration in Alaska in 1898, pp. 40-50. A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 265-340.

[b] Coal resources of southeastern Alaska: Bull. U. S. Geol. Survey No. 259, 1904, pp. 153, 154, 169-171.

[c] An abstract of this report has already been published under the title Preliminary statement on the Matanuska coal field: Bull. U. S. Geol. Survey No. 284, 1906, pp. 88-100.

GEOGRAPHY.

TOPOGRAPHY AND DRAINAGE.

The Matanuska Valley is a depressed area from 5 to 10 miles wide and about 100 miles long, extending in a northeast-southwest direction from a point near the southwest corner of the Copper River Plateau to the head of Knik Arm (Pl. I). It is bounded on the north by the Talkeetna Mountains and on the south by a part of the Chugach Mountains. Into each of these mountain masses extend many valleys of diverse size, shape, and physiographic character, but the fronts of both ranges lie in fairly distinct lines parallel to the general course of the river. The Talkeetna Mountains seem to be made up for the most part of ridges parallel to the river,

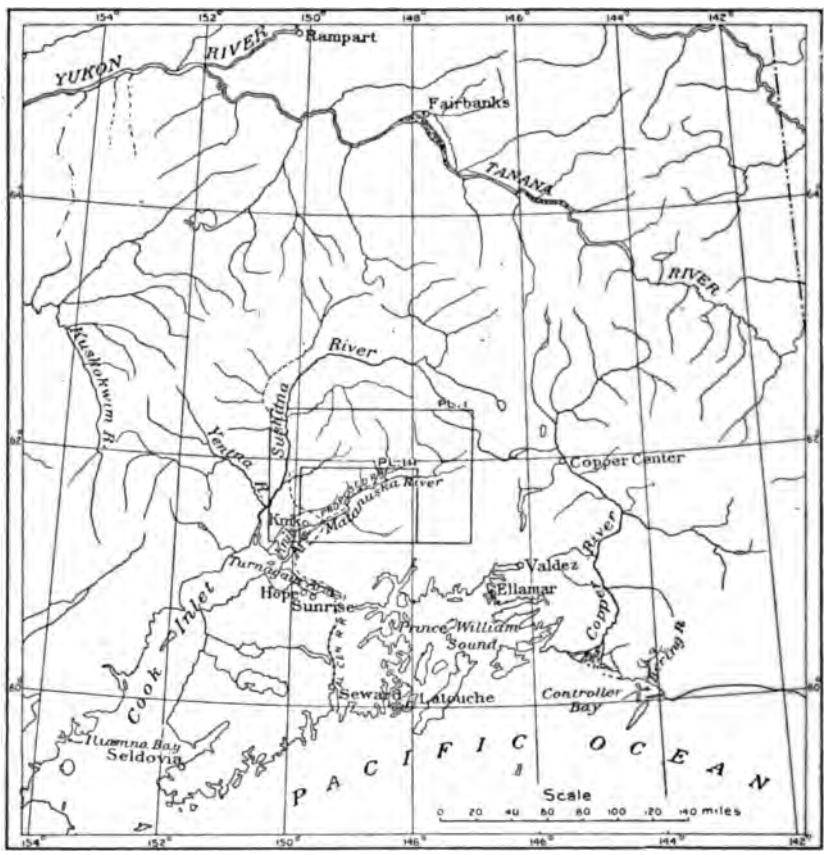


FIG. 1.—Outline map of region between Cook Inlet and Prince William Sound and the Tanana Valley, showing general location of Matanuska coal field and positions of large-scale maps.

while the Chugach Mountains consist chiefly of less regular masses. The general maximum elevation of each range is roughly about 5,000 to 6,000 feet, but there is no marked regularity in the height of the summits. The hills within the valley have elevations of 1,000 to 3,000 feet and increase in height to the east.

The river channel flows through many narrow gorges, but for most of its course in a valley from 1 to 2 miles wide (Pl. II, *A*), with walls rising steeply to an elevation of from 200 to 500 feet. This valley is in turn sunk within the broader one referred to above, whose width varies from 5 to 10 miles. The slope of this broader

A. MATANUSKA R

Looking down from near the mouth of Kings Cr

B. BOULDER CREEK, WITH ANTHRACITE RIDG

Showing the flood plain of Boulder Creek above t

AT LOW WATER.

lowing the general character of the lower valley.

THE MIDDLE BACKGROUND, FROM THE WEST.

, or where it is flowing on the old upland surface

valley descends from an elevation of about 2,800 feet at the mouth of Hicks Creek to about 2,000 near Chickaloon Creek and to about 600 feet at Tsadaka Creek.[a] From this point it descends more gradually until it is barely 100 feet above tide. The mouth of this broad valley may, in a general way, be considered to be near the mouth of Tsadaka Creek, for here it widens out into the great flats, from 1 to 20 miles in width, which extend all around the head of Cook Inlet.

Matanuska River rises in the southwest corner of the Copper River Plateau, in latitude 62° north and longitude 147° west (see fig. 1 and Pl. I). It flows in a westerly and southwesterly direction for an air-line distance of about 100 miles and empties into Knik Arm, the northernmost branch of Cook Inlet. Its volume fluctuates greatly according to the rainfall and state of melting of the snow and glaciers. The lower course of the river averages about 400 feet wide and 4 feet deep at low water, but reaches a width in some places of 2 miles, with a probable average depth of 10 feet at flood.

The tributaries, named in order from east to west, include Caribou, Hicks, Chickaloon, Kings, Granite, and Tsadaka creeks on the north side; and Matanuska Glacier, a large number of small creeks (mostly unnamed), and Knik River on the south side. Tsadaka Creek, which enters the Matanuska about 30 miles above Knik, is 12 miles long, drains an area of about 40 square miles, and is about 30 feet wide and 2 feet deep at the mouth. It can be bridged with a tree or forded almost anywhere. Granite Creek is of about the same size. Kings Creek is about 20 miles long, drains an area of 100 square miles, is 100 feet wide and 4 to 10 feet deep at the mouth, and has a velocity at many points of about 7 miles per hour. At several places on the lower course it is narrow enough to be bridged, and there are several fords. Its largest tributary is Young Creek. Chickaloon Creek (see Pl. IV) is 40 miles long and has a drainage basin of about 200 square miles. Its average width near the mouth is about 100 feet. The depth is probably 5 to 10 feet and the velocity in some places is 8 miles an hour. The largest tributary is Boulder Creek (see Pl. II, *B*), which enters it from the north and which is about as large as Tsadaka Creek. All these streams flow in part through broad, open valleys, and in part through box canyons.

The Matanuska has an elevation of about 3,000 feet at its source and falls at a gradually decreasing rate to about 850 feet at the mouth of Chickaloon Creek, to about 550 feet at the mouth of Kings Creek, to 470 feet at the mouth of Granite Creek, to 430 feet at the mouth of Eska Creek, and to about 300 feet at the mouth of Tsadaka Creek.

CLIMATE.

The climate of the Matanuska Valley offers no hindrance to the development of its mineral resources; on the contrary, it is such as to encourage not only mining, but even agricultural interests. The nearest points at which there are meteorological records are on Cook Inlet, and it will be useful to compare this valley with that region, of which it has been said:[b]

> The Cook Inlet region, including the lower part of the Sushitna basin, though somewhat colder than that part of the seaboard which lies directly on the open ocean, has probably the most delightful climate of any portion of Alaska. While the winters are cold compared with southeastern Alaska, the upper part of the inlet being usually locked in ice from November to May, they are not so severe as those of Bering Sea. The charm of the Cook Inlet climate is its bright, clear weather in the spring and summer, when there is just enough rainfall to insure ample water for the growth of vegetation.

[a] Commonly known as Moose Creek.

[b] Brooks, A. H., and Abbe, C., jr., General climatological features of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906, p. 145.

The following table is taken from the report just cited:

Temperature and precipitation on Cook Inlet.

	Temperature, °F.					Precipitation.			
	Maximum.		Minimum.		Mean.	Days with rain exceeding 0.01 inch.		Rainfall (including snow) inches per month.	
	Kenai.	Tyonok.	Kenai.	Tyonok.	Tyonok.	Kenai.	Tyonok.	Kenai.	Tyonok.
January	45	38	−40	−27	5.41	5.3	7.7	0.78	2.15
February	45	49	−32	−17	15.30	4.4	5.7	.70	.65
March	52	66	−34	− 9	23.60	7.4	4.5	.97	.71
April	58	59	4	1	37.70	6.4	4.0	.83	.88
May	66	68	20	22	43.10	6.4	3.7	1.01	.44
June	79	82	26	33	55.10	5.1	4.2	.73	.61
July	82	83	30	38	58.70	8.9	8.2	1.69	2.09
August	73	73	28	31	56.40	13.4	17.7	3.31	4.71
September	65	70	17	25	49.00	11.7	14.2	2.46	4.86
October	60	61	−10	10	35.40	10.0	12.2	2.06	4.15
November	44	44	−26	13	29.20	7.4	6.5	1.13	.88
December	45	49	−43	−21	17.00	6.0	7.2	.88	1.31
Year						92.4	95.8	16.55	23.44

The Matanuska Valley is somewhat colder and has less rain than Cook Inlet. The proportion of bright days in summer is probably greater at the head of Knik Arm than at any other point on the coast of Alaska. Conditions are practically the same throughout the Matanuska Valley as on Knik Arm, except as they are modified by differences in altitude.

It appears highly probable that the region bordering Knik Arm and part of the Matanuska Valley will support important agricultural industries. The district should become to a large degree not only self-supporting, but capable of supplying garden produce to such surrounding regions as are connected with it by adequate means of transportation.

VEGETATION.

The flats at the head of Cook Inlet are densely timbered with a small but fairly uniform growth of cottonwood, spruce, quaking aspen, and birch (the latter predominating), with a sparse undergrowth of alder, willow, currant, and huckleberry bushes. Scattered throughout the forests are broad meadows of excellent grass. A similar growth of timber extends throughout the valley of the Matanuska and its tributaries (see Pl. IV, *B*) up to an elevation of 2,000 feet. From this altitude to about 2,500 feet the timber becomes thinner (see Pl. II, *B*), and at a maximum elevation of about 2,800 feet it finally disappears.

The spruce is considered of good quality, though small. Some of it will square 12 inches, considerable of it 8 inches, and most of it 6 inches. There will probably be abundant timber for mining and local building purposes, especially as the supply will not be drawn on for fuel.

Those who are interested in the development of the region should, however, bear in mind that the cost of mining will depend very largely on the timber supply, and that though there seems now to be plenty for many years to come, yet great care will have to be used in preventing and extinguishing forest fires. Owing to the dry climate fires have already done great damage to standing timber. They are certain to become more frequent and extensive as the region is settled and especially as the timber is cut, and it is entirely possible that unless due care is used mining operations may be severely crippled through the destruction of the local timber supply.

TRANSPORTATION.

Knik, the post-office and shipping port for the entire region, is at the head of steamboat navigation on Knik Arm, and can be reached by an ocean voyage of seven to twelve days from Seattle to Seldovia and one or two days by local steamers on Cook Inlet. In 1905 steamers sailed from Seattle for Seldovia four times a month throughout the year, but navigation on Cook Inlet above Seldovia is usually closed from October 15 to April 20. The region can be reached at any time by leaving the steamer at Seward and going overland to the head of Cook Inlet. At present the railroad can be used for only the first half of the trip from Seward to Turnagain Arm, the rest being made on foot or with horses.

A good horse trail leads from Knik to the coal field. It requires a day or a day and a half to go from Knik to Tsadaka Creek, and a day from Tsadaka Creek to Chickaloon Creek. Matanuska River can be ascended under favorable conditions as far as Chickaloon Creek, or possibly farther in skillfully handled poling boats. But the best and cheapest way to move freight up the valley at present is with sleds in the winter. Summer freight can possibly be moved most cheaply with boats, but more safely with pack animals.

Supplies can be purchased at Knik, where there are two stores, and natives can usually be hired there. Horses can sometimes be hired at Knik, but it is not safe to depend on them unless they are engaged in advance.

The Alaska Central Railway, now under construction from Seward, on Resurrection Bay, toward the interior of Alaska, is planned to reach the Matanuska coal fields. This railroad was begun in 1904, and is now completed for 45 miles, with about 30 miles more under way. The railroad route leads northward from Seward, which is at the head of Resurrection Bay, across the mountainous Kenai Peninsula to the head of Turnagain Arm, along the north shore of that arm, and up the east shore of Knik Arm to the mouth of Matanuska River. The head of Turnagain Arm is 60 miles from Seward, the point where the railroad route leaves Turnagain Arm is 40 miles farther, and the mouth of Matanuska River is 140 miles from Seward. It is planned to have the road fork at this point, the main line going up the Sushitna Valley to the Tanana and a branch going up the Matanuska to the coal fields. The first coal will be reached on Tsadaka Creek, at a distance of 18 miles from the mouth of Matanuska River. The Kings Creek coal is about 34 miles, the Chickaloon Creek coal 38 miles, the Coal Creek coal 38 miles, and the anthracite coal 53 miles from the mouth of the Matanuska.

GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

The rocks in that part of the Matanuska region which was visited by the writer consist of granites and other coarse crystalline rocks bordering the valley on either side; Jurassic rocks known only from stream bowlders; coal-bearing sediments, partly Mesozoic and partly Tertiary, two distinct horizons apparently being represented; a large number and considerable variety of dikes and volcanic flows, and extensive sheets of gravels.

The sedimentary rocks of this region (exclusive of gravels) were called the "Matanuska series" by Mendenhall, who assigned them tentatively, on paleontologic evidence, to the lower Cretaceous. Mendenhall's description of the Matanuska series is as follows:[a]

After leaving Knik Arm for the trip to the interior by way of the valley of the Matanuska River no hard rocks are found in place until the trail descends into the valley of Tsadaka Creek, 40 miles

[a] A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 307-339.

from Palmer's store. For 40 or 50 feet above the bed of this creek, and underlying the loose gravels which fill all this part of the valley of the Matanuska, is to be seen an exposure of shales and sandstones with a few thin streaks of bright, hard coal. The beds remind one strongly in lithologic characteristics of the sediments of the lower coal measures in the Appalachian region. They are completely consolidated, although here not altered in the least, and have been disturbed so as to dip now about 25° NW. Across the Matanuska similar beds make the bluffs of the stream.

Opposite the mouth of Granite Creek the same beds are exposed, showing a fault of probably slight throw, and from this time until the Copper River Plateau is reached all rock exposures are of related sediments and intrusive beds.

With the data gathered on this reconnaissance it has not been found possible to subdivide them, so that they are all treated here as the Matanuska series.

The great mass of these beds are shales, similar physically to those first seen at Tsadaka Creek and displaying many colors, red, green, buff, and black being especially abundant. Besides shales, many coarser beds occur. Much the most important of these beds is the heavy conglomerate which makes the base of Castle Mountain and gives it its pinnacled and castellated outlines, so strikingly different from any of the neighboring hills and at once suggesting its name. This bed is probably not less than 1,000 feet thick, 600 feet of it having been measured, and the estimated height of the cliff above me at the time of the measurement being 300 to 400 feet. The heavy conglomerate plates, which together make up the mountain, are separated by thin, sandy shale sheets, which constitute but an insignificant quantity of the mass. The pebbles of the conglomerate contain a great variety of rocks, among them many igneous types. They are well rounded and vary in size up to a foot in diameter. Overlying the Castle Mountain bed is a body of soft, green shales with a cap of red sandstone. To the southwest this conglomerate is cut off by a great intrusive mass of porphyry, and northeastward it is probably dropped down by a fault of slight throw.

Other conglomerates occur on Hicks Creek and the headwaters of Caribou. These, however, are wholly different in character from the Castle Mountain bed, consisting generally of small, well-rounded pebbles of white quartz with but little extraneous material. The irregular occurrence of the Caribou Creek deposits appears to be best explained by the supposition that they were laid down in local channels cut in shales rather than in sheets. On Bubb Creek, a few miles below our camp of August 7 and 8, conglomerate cliffs about 200 feet high extend for half a mile along the stream, and represent either a broad channel or a slight anticline in the strata.

Limestone nodules occur at a number of places in the shale, but only one bed of any extent appears along our route. It was first seen as a gray cliff forming a scarp around the hilltops just before Limestone Gap was reached. Dips bring it lower as the gap is approached, and the trail passed over it, but it rises again and disappears from the hills along the upper course of Bubb Creek within a few miles of its source. The thickness is about 300 feet.

* * * * * * *

A few fossils were collected at the base of the limestone bed at the head of Bubb Creek and submitted to Mr. T. W. Stanton for examination. He says:

"The fossils * * * have been examined and found to consist of numerous examples of *Aucella crassicollis* Keyserling and a few fragments of a *Belemnites* which can not be identified specifically. The species determined is sufficient to fix the age of the bed from which they came as lower Cretaceous."

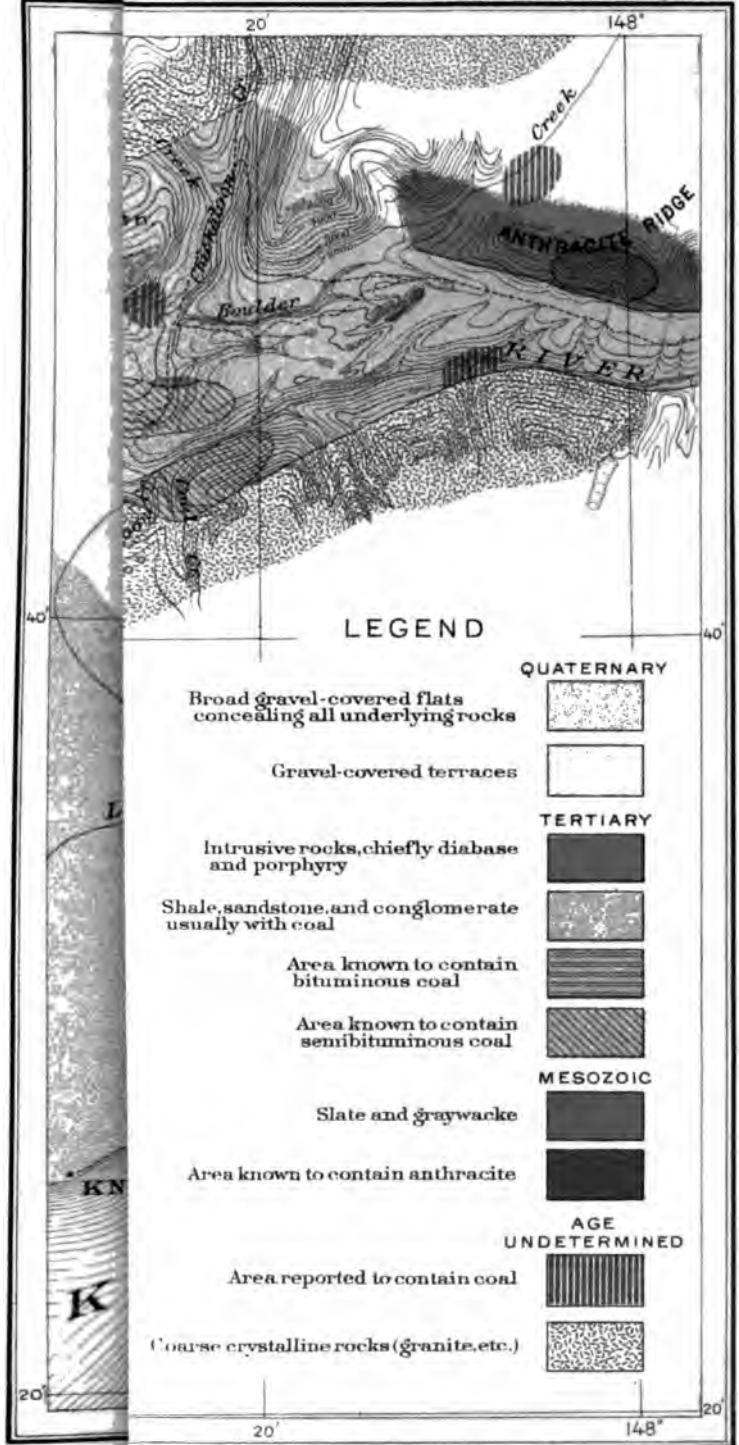
On the basis of this determination the whole series is tentatively assigned to lower Cretaceous, or an older period, since the limestone bed appears to occur near the top of the series. Fragmentary fossil leaves of well-developed exogenous types were collected at a number of places, but, being impressions on a very fragile matrix, were crushed in the attempt to transport them to the coast by pack trains.

As a result of further work, however, it appears that this "Matanuska series" contains beds of several ages, while the beds in the greater part of the Matanuska Valley, including all of those seen by the writer in the immediate vicinity of the river, are not Cretaceous. For these reasons it seems best not to employ the term in the original sense. Our present knowledge is so imperfect that it is not advisable either to restrict the term or to define new formations which can be included within it. Consequently in the following discussion the rocks will be grouped according to age and lithologic character and described without formation names.

The areal distribution of the several rock masses is shown on the geologic map (Pl. III) and the structural relations as far as are known are indicated in fig. 2.

COARSE CRYSTALLINE ROCKS.

The crystalline rocks occur in the high mountains on either side of the Matanuska Valley. They are known to the writer only from the stream bowlders, from the reports of prospectors, and from the appearance of the mountains as seen from a dis-


20'
148°
Creek
ANTHRACITE RIDGE
Boulder
RIVER
40'
LEGEND
QUATERNARY
Broad gravel-covered flats concealing all underlying rocks
Gravel-covered terraces
TERTIARY
Intrusive rocks, chiefly diabase and porphyry
Shale, sandstone, and conglomerate usually with coal
Area known to contain bituminous coal
Area known to contain semibituminous coal
MESOZOIC
Slate and graywacke
Area known to contain anthracite
AGE UNDETERMINED
Area reported to contain coal
Coarse crystalline rocks (granite, etc.)
20'
148°

tance. They appear to consist chiefly of granite, though a variety of other rocks, including greenstone, is present. The position of these belts is shown approximately on the map (Pl. III). The areas thus mapped are certainly predominantly crystalline, but may possibly include some masses of sediments which are probably Mesozoic or older.

The relation of these rocks to the sedimentary rocks, described below, is not definitely known. They may be late Tertiary or post-Tertiary intrusive masses, or the contact may be one of faulting. The writer is inclined to believe, largely from analogy with other regions, that they are plutonic masses of early Mesozoic or pre-Mesozoic age against which the Tertiary rocks have been faulted. Further discussion of this problem is presented in the section on structure (p. 17).

MESOZOIC STRATA.

The Mesozoic rocks, which may represent one or more horizons, are known only from bowlders, from outcrops seen only in the extreme east end of the region visited by the writer, and from outcrops in localities still farther east which were reported by Mendenhall.

Bowlders of dark, flinty sandstone of very different lithologic character from anything seen in place by the writer were found in the bed of Chickaloon Creek. It contains many specimens of *Aucella*, determined by T. W. Stanton to be "of the type of *Aucella pallasi* Keyserling, an upper Jurassic species." The presence of upper Jurassic rocks in the Talkeetna Mountains is thus established. The bowlders were much worn and not abundant, indicating that the outcrops of these beds are at a considerable distance from the Matanuska.

Other Mesozoic beds of less definite age were seen on the summit and southern slope of Anthracite Ridge, which is a long, sharp-topped mountain (see Pl. II, *B*), about 5,500 feet high, bordering the north side of the Matanuska Valley between Boulder and Hicks creeks. This ridge is part of the southern front of the Talkeetna Mountains. It consists chiefly of graywacke, with numerous calcareous concretions and beds of sandstone, intrusive masses of diabase, and several beds of anthracite coal. A very few fragmentary fossils were obtained, partly from the summit and partly from an elevation of 3,450 feet on the southern flank of the ridge. Stanton says of them:

> The very small and fragmentary lot (No. 3318) from this locality (elevation 5,500 feet) contains a *Nucula* and fragments of the fibrous shell of an *Inoceramus*. So far as can be determined from these specimens the horizon may be as low as middle Jurassic or as high as upper Cretaceous. It is certainly not outside of these limits.
>
> This lot (No. 3319, from elevation 3,450 feet) includes a very young ammonite not generically determinable, a fragment of another ammonoid which apparently belongs to some loosely coiled form like *Hamites*, a part of the phragmacone of a *Belemnites*, several species of a small *Ostrea*, and fragments of *Inoceramus* shell. The remarks concerning the age of No. 3318 are applicable to this lot also.

Rocks of possibly the same age were seen by Mendenhall near the headwaters of Bubb and Caribou creeks, about 25 miles northeast of the last-mentioned locality. Mendenhall says:[a]

> Limestone nodules occur at a number of places in the shale, but only one bed of any extent appears along our route. It was first seen as a gray cliff forming a scarp around the hilltops just before Limestone Gap was reached. Dips bring it lower as the gap is approached and the trail passes over it, but it rises again and disappears from the hills along the upper course of Bubb Creek within a few miles of its source. The thickness is about 300 feet.

His notes are more explicit and read:

> In the head of the stream rising on the east side of Limestone Gap, at the beginning of the limestone gorge about a mile from the gap, is a curious exposure of mingled conglomerate and fossil-bearing rocks. The shells are embedded in a sand matrix and are often only casts. These beds are at the base of the limestone as exposed here. The limestone, however, seems to be high up in the sedimentary series. The limestone lies in a syncline, at the deepest point of which the fossils were gathered. East of this dips are westward and rocks mostly soft shale.

[a] Op. cit., p. 308.

The fossils were submitted to T. W. Stanton, whose report upon them has been quoted on p. 10.

TERTIARY STRATA.

The rocks in the valley of the Matanuska from Chickaloon Creek to Tsadaka Creek consist chiefly of shale and sandstone, with many coal beds and at least one bed of massive conglomerate.

The conglomerate belongs near the top of these rocks (see Pl. IV, *B*), which altogether can not be less than 3,000 or 4,000 feet thick. Mendenhall reports the following section in Castle Mountain:

Section of Tertiary rocks in Castle Mountain.

	Feet.
Red sandstone (?)	400 –
Soft green rock	200 +
Conglomerate	1,000

The interval between the conglomerate and the beds exposed at the base of the mountain on Chickaloon and Kings creeks is not known. The following sections were measured by the writer:

Section at bend of Chickaloon Creek, one-half mile above Watson's camp.

		Ft.	in.
1.	Gray shale with occasional concretions	16	
2.	Hard clay shale, nodular	2	6
3.	Fissile gray shale with iron balls	16	
4.	Dark-gray limestone	1	
5.	Dark fissile shale	4	6
6.	Micaceous sandstone	2	6
7.	Dark liver-colored fissile shale containing strata of iron concretions	2	
8.	Arkose	1	
9.	Dark fissile shale	12	
10.	Iron ore		3
11.	Black shale		9
12.	Carbonaceous shale and bone		6
13.	Black shale	3	
14.	Dark fissile shale with many strata of ironstone nodules	33	
15.	Carbonaceous shale	2	
16.	Dark shale with thin strata of ironstone balls	23	
17.	Ironstone with fossil gasteropods		6
18.	Dark shale with many streaks of iron ore	6	
19.	Soft black carbonaceous shale	6	
20.	Ironstone		6
21.	Dark fissile shale with bands of ironstone	35	
22.	Massive sandstone[a]	10	
23.	Black shale		6
24.	Coal, with some bone and shale	11	
25.	Shale and sandstone	10	
26.	Coal, with some bone and shale	8	9
27.	Dark shale	6	
28.	Dark shale with coal streaks	2	
29.	Shale with sandstone and ironstone bands	19	
30.	Sandstone with sandy shale bands	9	
31.	Shale	1	
32.	Coal, impure, much distorted and changed by heat	5	6
33.	Shale with iron bands	9	
34.	Sandstone (in roll)	4	6
35.	Shale	7	
36.	Igneous intrusion (sill) of diabase, with local occurrence of natural coke on top	11	
37.	Irregular mass of coal and carbonaceous matter much distorted by the dike	15	
		300	3

[a] Shown in the base of the cliffs at the right in Pl. IV, *B*. All the underlying beds in this section are also shown in the photograph.

The rocks are concealed for a short distance below this section, but the stratigraphic interval is very small, surely not over 100 feet. The following section then appears:

Section at Watson's camp, Chickaloon Creek.

		Ft.	in.	Ft.	in.
1.	Shale			10	
2.	Coal	9	4	9	4
3.	Shale			9	
4.	Coal	1			
5.	Shale	1		2	6
6.	Coal		6		
7.	Gray concretionary shale			14	6
8.	Massive sandstone			13	6
9.	Sandstone and shale			50	
10.	Possibly small concealed interval.				
11.	Shale			10	
12.	Coal	1	8		
13.	Shale		6		
14.	Bony coal	1	8	10	10
15.	Shale		10		
16.	Coal	6	2	6	
17.	Shale			28	
18.	Possibly concealed, not over			10	
19.	Shale			3	
20.	Coal (1 ft. 8 in. to 3 ft. 7 in.)	2	8	2	8
21.	Shale			8	
				187	4

The following sections come closely below, not over 100 feet intervening:

Section on west bank of Chickaloon Creek below Watson's camp.

		Ft.	in.
1.	Massive sandstone.		
2.	Shale	2	6
3.	Coal	1	
4.	Shale with coal streaks and iron ore concretions (approximation; beds contorted)	44	
5.	Shale with coal streaks and large concretions	22	
6.	Gray massive sandstone	9	6
7.	Dark shale with nodules and coal streaks	22	
8.	Gray sandstone with shale streaks	5	7
9.	Shale with coal streaks	12	
10	Limestone	1	6
11.	Gray shale	5	10
12.	Gray sandstone with many sticks	9	7
13.	Gray shale	3	6
14.	Gray sandstone	3	6
15.	Gray shale with coal streaks	13	
16.	Impure limestone	2	6
17.	Dark soft shale with leaves and coal streaks	5	
18.	Coke	1	6
19.	Baked shale and coke	1	
20.	Volcanic bed (varies from 1 to 5 feet), average	2	6
21.	Gray and black shale	10	4
22.	Reddish sandstone	2	6
		180	10

The rocks on Kings Creek near the upper bridge appear to belong at approximately the same position as those just described on Chickaloon Creek.

Section on east bank of Kings Creek above upper bridge.

		Ft.	in.	Ft.	in.
1.	Volcanic flow			50+	
2.	Shale			69	
3.	Sandstone with shaly bands			9	
4.	Coke	1			
5.	Shaly sandstone		8	2	2
6.	Coal		6		
7.	Black shale			6	
8.	Shale with thin coal streaks			5	
9.	Sandstone				6
10.	Impure coal	3		3	
11.	Shale			13	
12.	Coal	1		1	
13.	Fissile shale			20	
14.	Sandy shale			10	
15.	Fissile shale			51	
16.	Shale			30	
17.	Massive sandstone			3	
18.	Concealed, 30 to 60 feet			45±	
19.	Shale			12	
20.	Shaly sandstone			4	
21.	Shale			13	
22.	Coal with many shale bands	6		6	
23.	Sandy shale			6	
24.	Coal (as on p. 23)	10		10	
25.	Carbonaceous shale			10	
26.	Massive sandstone			6	
27.	Shale			10+	
28.	Sandstone.				
				394	8

Strike N. 28° W.

These beds have yielded fossils at two points on Chickaloon Creek and at one on Kings Creek. The uppermost fossiliferous bed on Chickaloon Creek is the thin ironstone (No. 17) in the section on page 12. Stanton reports on these fossils as follows:

This lot (No 3316) consists entirely of fresh-water gasteropods, of which all but one specimen belong to a single species of *Viviparus* of a type that occurs in both the upper Cretaceous and the Tertiary. The other specimen is a more slender form, too imperfect for generic determination. These fossils are apparently an undescribed species—at least they are new to Alaska—and they do not fix the horizon more closely than is above indicated.

The other fossil bed on Chickaloon Creek is the roof of the coal (No. 2) in the section on page 13. The fossils consist entirely of leaves, of which F. H. Knowlton says:

I find the following species:

Taxodium distichum miocenum (Brgt.) Heer.
Salix varians Heer.
Populus arctica Heer.
Corylus macquarrii (Forbes) Heer.
Juglans nigella Heer.

The age indicated is Kenai.

The other locality is not exactly known, but is at some place on Kings Creek, where a few fossil leaves were collected by Mr. W. A. Langille, of the Forest Service. Knowlton reported on them as follows:

The specimens are small and the plants fragmentary and poorly preserved. With some uncertainty I am able to recognize the following species:

Taxodium tinajorum Heer.
Sequoia langsdorfii (Brgt.) Heer.
Populus arctica Heer.
Corylus macquarrii (Forbes) Heer

If these determinations have been correctly made, and it seems probable that they have, the age should be "Arctic Miocene" or Kenai. But it should be added that more and better material will be needed before the position can be positively determined.

It may be seen from the foregoing that there is little doubt that part, at least, of these beds are approximately of the same age as the coal-bearing rocks at Homer, on Cook Inlet, which are generally considered to be middle Tertiary (Oligocene).

GRAVELS.

The valley of the Matanuska and its tributaries from the head of Cook Inlet to somewhat above Chickaloon Creek is covered with thick deposits of coarse gravels, which occur in a series of benches or terraces, often concealing all of the hard rocks. These extend from 50 to 300 feet above the river bed and have a general elevation which rises toward the east from about 100 feet on the shores of Knik Arm to about 450 feet at Tsadaka Creek and to about 1,000 feet at the mouth of Chickaloon Creek. The best exposures of these gravels are at the point where the trail crosses Tsadaka Creek and at the lower ford at Kings Creek. These gravels contain bowlders of diverse character and vary in size from fine sand to material a foot or more in diameter. It is reported that they carry very small amounts of gold, but, so far as known, not enough to be of value even where the gravels have been reworked by the streams that are cutting through them.

These gravels were probably of original glacial origin, but were laid down in their present position by water, either in a large stream at considerable distance from the glaciers or in an arm of the sea. The approximately level surfaces of the terraces and the fact that there is a more or less definite altitude, above which the gravels are not found, indicate that the distribution of the gravels was at least controlled by the position of the sea. If so it was during a period when the land stood at a lower relative level than it does now, and that period was followed not only by elevation of the land, but by tilting.[a] It is not, however, the opinion of the writer that these deposits in themselves necessarily indicate much greater extent of the glaciers than exists at present There undoubtedly has been a somewhat greater extension of the existing glaciers, but these gravels may or may not have been contemporaneous with it.

DIKE ROCKS.

There are numerous dikes throughout the greater part of the Matanuska Valley. They are more frequent and larger toward the upper end of the valley and are also more numerous wherever folding and faulting was strongest. The most important of them are shown on the map (Pl. III), from which, however, by far the larger number are omitted on account of their small size and of the incomplete character of the investigation.

Diabase.—Dikes and sills of diabase are very abundant in both the Mesozoic and the Tertiary rocks. The base of the front of the Talkeetna Range between Bowlder and Hicks creeks is marked by a zone of faulting and sharp folding. Large masses of basic diabase have been intruded parallel to the strike along this zone and are responsible, in part at least, for the anthracitic character of the coal. The rock is somewhat altered, containing serpentine and an altered glassy base in addition to basic plagioclase and augite. The largest of these dikes is of fairly coarse grain. A dike of similar composition but finer grain, mentioned by Mendenhall,[b] cuts across Chickaloon Creek, about 2½ miles below the ford (not at the head of Chickaloon Creek). This dike is very prominent because of the ridge which it makes, and because of the gorge produced in the creek at this point. The coal-bearing rocks for

[a] Mendenhall, W. C., A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 315-316, 328-330.
[b] Op. cit., p. 310.

a mile below this point are cut by numerous small dikes and sills of the same rock, which, wherever it comes into close proximity with the coal, alters it to a dense, hard coke. One of these sills is shown at the left in Pl. IV, *B*. Dikes of this general character are common throughout the greater part of the coal field and always have this effect on the coal.

Porphyritic rocks.—A large intrusive mass occupies the mountain south of Kings Creek and immediately west of the trail. (See map, Pl. III.) This has been described by Mendenhall,[a] as follows:

> The first mass detected in the summer's reconnaissance forms a part of the north wall of the valley just below Kings Creek. Although its limits are not known except on the valley side, it is presumably of considerable extent, since the mountain from which this specimen was collected appears to be homogeneous and continuous for several miles northeast and southwest from Kings Creek crossing. The rock is a light-gray, fine-grained porphyritic mass, which appears under the microscope to be a quartz-diorite porphyry carrying a light-green hornblende. Microscopically it exhibits no evidence of mechanical deformation. There was no opportunity to search for a contact, but the porphyry is considered to be later than the surrounding sediments and intrusive in them, because these latter do not exhibit either the structure or the lithologic characteristics which we would expect had the porphyry served as a base upon which the sediments were deposited.

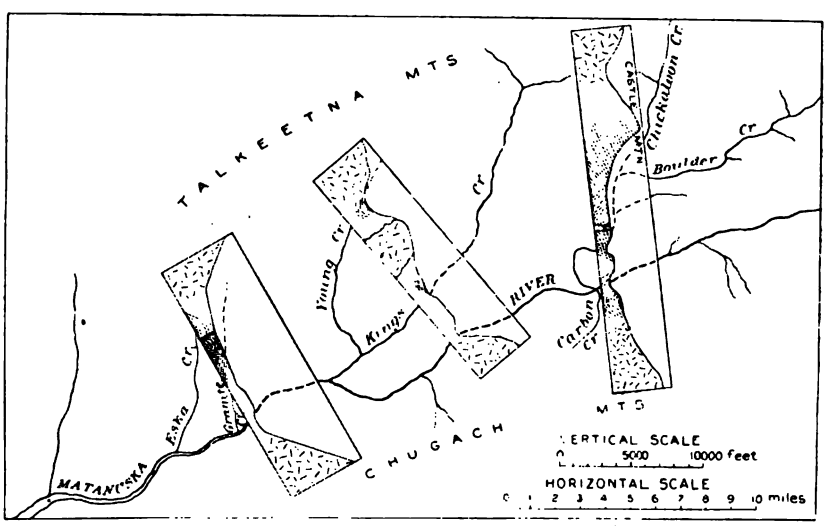


FIG. 2.—Sections showing structure of Matanuska Valley.

At the upper bridge over Kings Creek, 3 miles above the locality described by Mendenhall, is a sheet of porphyritic rock apparently interbedded in the Tertiary coal-bearing rocks. The relations are shown in the section above. This rock appears under the microscope to be made up largely of holocrystalline porphyritic feldspars—chiefly plagioclase, though orthoclase is also abundant—in a groundmass of chlorite, magnetite, quartz, and calcite. The character of the original ferromagnesian constituents could not be determined. The rock is of intermediate type, possibly being a porphyritic monzonite. It is probably either an apophysis or a flow from the porphyritic mass described by Mendenhall.

STRUCTURE.

The Matanuska Valley follows a zone of soft Tertiary shales and sandstones, with some conglomerates and igneous rocks, the whole included within two parallel masses of plutonic rocks which are associated with Mesozoic sediments. The Tertiary belt

[a] Op. cit., pp. 309–310.

A. CASTLE MOUNTAIN

B CLIFFS ON WEST BA

Showing coal bed, sill, an

KALOON CREEK.

KALOON CREEK.

ction on p. 12.)

is from 7 to 8 miles wide and has fairly straight and parallel boundaries which are the topographic limits of the greater valley within which the Matanuska flows. (See Pl. III.) It is suggestive of a "graben" or sunken area within parallel faults, but this appearance may be due to the more resistant character of the rocks bounding the valley. The structural relations along the lines of contact of the Tertiary with more massive and presumably older rocks are not known.

The Tertiary rocks are involved in a system of folds and faults. The folds are open and the faults often cut the axes of the folds. The general strike is parallel to the course of the Matanuska, being N. 60° E. below Chickaloon Creek and N. 75° to 90° W. above Chickaloon Creek. There seem to be several approximately parallel folds with either sinuous or offsetting axes. The character of this structure on local cross sections is shown in the sections in fig. 2. The section through Castle Mountain and Coal Creek shows the monoclinal northwestward dip of Castle Mountain, a syncline with a basaltic dike at or near its axis on Chickaloon Creek, an anticline with its axis somewhere near the mouth of Chickaloon Creek, and a syncline crossing Coal Creek about a mile above its mouth. The next section shows a syncline on the headwaters of Young Creek, the large porphyritic intrusion in the hill to the southeast, and indeterminate structure in the flats to the south. The section down

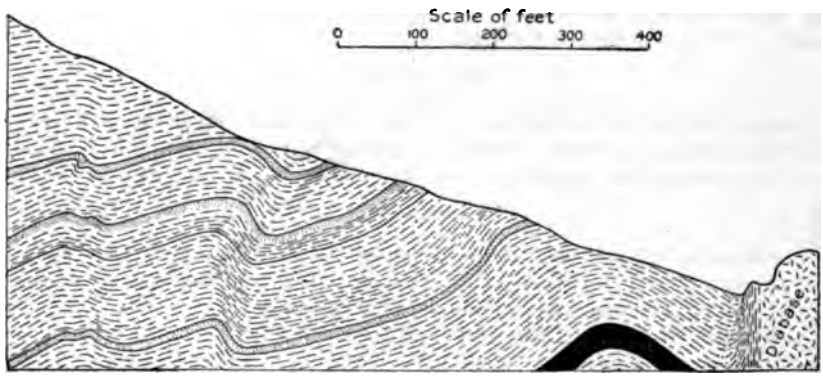


FIG. 3.—Section of part of south face of Anthracite Ridge.

Eska Creek shows several folds, the northwesternmost being a probable anticline with strongly faulted axis, followed on the southeast by a syncline, beyond which is another anticline. The observations of strike and dip on Tsadaka Creek show a general northwesterly dip, with a single outcrop showing easterly dip. It is not possible from present knowledge to connect these axes and determine whether there are a few long, sinuous folds or whether there is an offsetting of axes by complex pitch or by cross or diagonal faults.

The Mesozoic anthracite-bearing rocks east of Boulder Creek are more complexly folded, as is shown in fig. 3, than the Tertiary rocks of the center of the valley. They are separated from the latter by a fault or system of faults parallel to the axes of folding.

The igneous rocks are intruded partly parallel to the axes of folding as long and fairly persistent dikes, partly parallel to the bedding as sills (there may also be interbedded flows), and partly as large masses like the boss on the west side of Kings Creek.

MINERAL RESOURCES

COAL.

AREAL DISTRIBUTION.

Coal outcrops have been seen by the writer on Tsadaka, Eska, Kings and its tributaries, Chickaloon, and Coal creeks; on the small creeks heading in the Talkeetna Mountains between Boulder and Hicks creeks; and in the banks of Matanuska River about 3 miles above the mouth of Chickaloon Creek (see fig. 4). They have also been reported from Boulder, Hicks, and Caribou creeks, from a creek on the south side of the Matanuska 9 miles above Coal Creek, and from Little Sushitna River.

The extent of the area underlain by coal is not very definitely known. There is a coal area of at least 70 square miles in the valley of the Matanuska and its tributaries from Tsadaka Creek to Hicks Creek inclusive. This is a conservative estimate based on outcrops actually known to the writer. It is possible that there is a larger area than this, but it seems certain from present knowledge that the total area of coal-bearing rocks in the region indicated above can not in any case exceed 300 square miles except by further extensions of this field or neighboring fields outside the region visited by the writer, which might increase the area to limits which we have no means at present of knowing.

POSITION AND SECTIONS OF THE COAL.

There are at least two distinct kinds of coal in this region, occurring at two widely separated geologic horizons. One is the anthracite coal, which is of Mesozoic age, and the other includes various grades of bituminous coal, which are of Tertiary age.

ANTHRACITE.

The Mesozoic coal, as stated above, is apparently all anthracite. It was seen by the writer only along the flanks of the Talkeetna Mountains, between Boulder and Hicks creeks. This coal has the ordinary physical characteristics of most good coal of this kind. It is heavy, firm, hard, and not much fractured for surface coal, and has a high luster. Pyrite was not noticed. The seams are not much broken by small partings of shale and bone.

Two sections were measured. On the south bank of Purinton Creek, at an elevation of 3,410 feet, an exposure was measured which showed 38 feet of clean, solid coal, both roof and floor being concealed (see analysis No. 1, p. 27, which represents the entire thickness as measured). At this point the strike is N. 40° E. (magnetic) and the dip is 10° NW., or into the mountain. The rocks in the vicinity are chiefly graywacke and sandstone, and show considerable variation of strike and dip (see Pl. V. and fig. 3). A short distance downstream is a good-sized mass of diabase occupying the axis of an anticline, which is in other places broken by a fault. The anthracite is probably restricted to a zone, along the face of and in the mountains, which is cut off from the valley plateau by a fault following the base of the mountains. Black streaks that are probably coal could be seen high up on the face of the mountain, and could be followed by the eye for several miles. About 1 mile northeast of the locality described above, and at an elevation of about 3,460 feet, a coal section gave the following measurements:

A. FOLDS AND ANTHRACITE COAL

B. THE SAME FOLDS ABOUT

SOUTH SIDE OF ANTHRACITE RIDGE.

E-HALF MILE FARTHER EAST.

Section of coal on slope of Talkeetna Mountains.

	Ft.	Ft.
Flaggy sandstone.		
Coal and shale	3	10
Coal	7	
Shale		4
Coal	1	1
Shale		3
Coal	2	2
Shale		2
Coal	7	7
		29

Strike N. 60° E., dip 55° SE.

The general strike along the side of the mountain is N. 75° E. (magnetic). The area of anthracite was not estimated by the writer, and the amount available for economic mining and shipment may possibly not be sufficient to justify the necessary expenditures. On the other hand, the field may, as has been reported by some, extend far beyond the areas visited by the writer, both eastward beyond the valley of Hicks Creek and northward into the valley of Boulder Creek. Later information indicates that the eastern continuation of the coal is of lower grade, being bituminous and intermediate in character between the Chickaloon and the Tsadaka Creek coal.

BITUMINOUS.

Eastern district.—The coal included under this heading, probably all of Tertiary age, was seen by the writer on both sides of the Matanuska in the vicinity of Chickaloon Creek and in the valleys of Chickaloon and Kings creeks. Coal has been reported for a considerable distance along the linear extension of this belt to the east, but the amount and quality of the coal is not known.

The coal in this area all possesses about the same physical characteristics and, as will be seen by the analyses (pp. 27 and 28), the variation in chemical composition is not great, and supports this grouping. It has the ordinary properties of most bituminous coal. It is soft and fragile, but often without any well-defined planes of fracture. It burns with a short flame and a small amount of smoke, and possesses distinct caking properties. The seams generally contain a large amount of impurities, both in the form of thick partings of shale and as thin bands of shale and bone. Many of these can not be separated in mining. The coal is soft and friable, and much of it will not stand severe handling without crushing. Pyrite is present both as balls and as scales, but not abundant. The friable character of the coal is not a great detriment when it is considered that much of it will probably have to be crushed and washed (especially for coke making) and that the coal, when used for steam or heating, will cake as soon as put in the furnace, so that there will consequently be little or no loss through the grates.

The following sections were obtained on the south side of the Matanuska, near the mouth of Chickaloon Creek:

Section of coal beds on south bank of Matanuska River 3 miles above the mouth of Chickaloon Creek.

	Ft.	in.	Ft.	in.
Gray shale			10	
Coal		6		
Shale		1	7	7
Coal[a]	7			
Gray shale with ironstone bands			42	
Coal		6		
Shale	1	6	7	
Coal	5			

[a] Included in samples Nos. 7 and 8; see analyses, p. 27.

Section of coal beds on south bank of Matanuska River 3 miles above mouth of Chickaloon Creek—Continued.

	Ft.	in.	Ft.	in.
Gray shale			7	
Coal		6		6
Shale			4	6
Coal		8		
Shale		1	6	5
Coal	5	8		
Soft gray shale			20	
Concealed to river.				

Strike N. 36° E. (magnetic), dip 44° SE.

Section on north bank of Coal Creek, elevation 1,010 feet.

	Ft.	in.	Ft.	in.
Soft dark shale			10	
Coal [a]	2	2		
Parting.				
Coal [a]	1	5	5	
Sandstone		2–6		
Coal [a]	1			
Soft shale			10+	

Strike N. 64° E., dip 70° SE.

Section on north bank of Coal Creek, 500 feet upstream from section given above.

	Ft.	in.	Ft.	in.
Intrusive sheet and coke			12	
Coke	5		5	
Intrusive sheet with coke			14	
Shale			10	
Coal [b]	6	3		
Shale		2		
Coal [b]		6	8	7
Shale		11		
Coal		9		
Soft shale floor.				

Strike and dip as above.

A section on Coal Creek, one-half mile above the lower coal shows coal about 6 feet thick, with a strike of N. 60° E. and a dip of 55° NW.

The following sections were measured on Chickaloon Creek:

Condensed section [c] of coal-bearing rocks on Chickaloon Creek.

		Ft.	in.
1.	Shale with many thin iron-ore bands	180	
2.	Coal with some bone and shale (as on p. 21)	5	4
3.	Shale	4	
4.	Coal with some shale (as on p. 21)	4	10
5.	Shale and sandstone (horse)	10	
6.	Coal with some shale (as on p. 21)	8	9
7.	Shale and sandstone	37	
8.	Coal, impure and somewhat coked	5	6
9.	Shale and sandstone	20	
10.	Diabase sill with local occurrence of natural coke on top	11	
11.	Coal and coke with impurities in an irregular distorted mass	15	
12.	Concealed (not over)	100	
13.	Shale	10	
14.	Coal with some shale (as on p. 22)	9	4
15.	Shale	9	
16.	Coal with some shale (as on p. 13)	2	6

[a] Included in samples Nos. 9 and 10, see analyses, p. 27.
[b] Included in samples Nos. 11 and 12; see analyses, p. 27.
[c] For details see local section on pp. 12–14 and the sections of coal seams which follow.

Condensed section of coal-bearing rocks on Chickaloon Creek—Continued.

	Ft.	in.
17. Shale and sandstone	88	
18. Coal with bone and shale (as on p. 22)	10	10
19. Shale	41	
20. Coal (varies from 1 ft. 8 in. to 3 ft. 7 in.)	2	8
21. Shale with some sandstone, iron ore, and volcanic beds, and a few thin beds of coal and coke	180	

Section at bend of Chickaloon Creek, one-half mile above Watson's camp, showing details of beds 2 to 6 in condensed section.

	Ft.	in.	Ft.	in.
Black shale			1	6
Coal		7		
Coal, bony		4		
Shale		5		
Coal		6	5	4
Shale, black	1	6		
Coal	2			
Concealed			1	
Shale			3	6
Coal		7		
Shale		8		
Coal		10	4	10
Shale		6		
Coal	2	3		
Shale and sandstone (horse)			10	
Coal		6		
Shale, with coal stringers	1			
Coal		10		
Shale		4		
Coal		2	8	9
Shale	1			
Coal		6		
Shale		1		
Coal	4	4		
Shale			6	

The following section probably represents some of the distorted beds in the lower part of the section on page 12, or Nos. 6 to 11 in the condensed section on page 20. The dip appears to be overturned.

Section in tunnel No. 2, Chickaloon Creek.

	Ft.	in.	Ft.	in.
Shale (at mouth of tunnel)			20	
Coal	6		6	
Hard shale			17	6
Bone[a]		10		
Coal[a b]		2		
Coal, with some bone[a]	2	5	5	3
Coal[a b]	1	10		
Shale and bone			2	8
Bony coal[a]		6		
Coal[a b]		11		
Bone[a]	1	11		
Coal[a b]	2	4	7	2
Bone[a]		5		
Coal[a b]		8		
Bone		5		

Hard shale.

Dip almost vertical toward mouth of tunnel.

[a] Included in sample No. 2; see analysis, p. 27.
[b] Included in sample No. 3, see analysis, p. 27.

The following sections give the details of Nos. 14 and 18 of the condensed section:

Section in opening No. 3 near Watson's camp, Chickaloon Creek (No. 14 of condensed section).

	Ft.	in.	Ft.	in.
Shale			10	
Coal	1	4		
Shale		6		
Bone		6	9	4
Coal[a]	7			
Shale with coal streaks			4	6

Strike N. 72°., dip 72°, 75°, 83° NW.

Section in tunnel No. 5, Chickaloon Creek (No. 18 of condensed section).

	Ft.	in.	Ft.	in.
Shale			10	
Coal[b]	1	8	1	8
Shale				6
Bony coal			1	8
Shale				10
Coal[b]	6	2	6	2
Shale			28	

Strike N. 62° E., dip 51° NE.

The coal seams exposed or opened on Kings Creek gave the following sections:

Section in tunnel on east bank of Kings Creek, 100 yards above upper bridge.

	Ft.	in.	Ft.	in.
Dense impure coke	5		5	
Bony shale			1	
Coal	1			
Shale		1		
Coal		8		
Bone		1	6	3
Coal	1	2		
Bony coal		9		
Coal	2	6		
Hard shale.				

This section probably represents the 6 feet of impure coal of No. 22 in the section on page 14, and is the same seam as the following:

Section in open cut, 10 feet south of last opening.

	Ft.	in.
Coal (no cover)	3	
Shale		2
Coal	1	2
Soft impure coal		2
Coal	1	8
Shale		3
Coal		3
Shale and coal		7
Coal	2	8
Hard shale floor.		
	9	11

[a] Included in sample No. 5; see analysis, p. 27.
[b] Included in sample No. 6; see analysis, p. 27.

The following section gives the details of No. 24 in the section on page 14:

Section in opening on west bank of Kings Creek at upper bridge.

	Ft.	in.
Coal[a]	2	5
Sandstone		2
Coal[a]	1	4
Shale		1
Coal	1	5
Sandstone		1
Bony coal[a]	1	
Sandstone		1
Coal[a]	3	4
	9	11

Strike N. 42° W. (magnetic), dip 42° NE.

The coal on Young Creek is of intermediate character between that on Kings and Chickaloon creeks and south of the Matanuska and that in the west end of the field on Eska and Tsadaka creeks. It is reported that one or more seams of workable thickness have been found, but the following is all that was seen by the writer:

Section on west bank of Young Creek, at elevation of 1,585 feet.

	Ft.	in.	Ft.	in.
Shale			10	
Sandstone			2	
Shale			4	
Sandstone			1	
Shale			4	
Coal[b]	1		1	
Shale			15	
Coal	6		6	
Shale with sandstone bands			15	
Sandstone			1	
Shale			10	

Strike N. 15° E. (magnetic), dip 20° NW.

Western district.—The coal in the west end of the bituminous belt, as seen on Eska and Tsadaka creeks, has been considered locally as lignite. The analyses, however, indicate that it is in all probability a low-grade bituminous coal, and this conclusion is supported by the fact that the coal does not differ greatly in physical properties from some of that on Chickaloon and Kings creeks. The seams have about the same characteristics as those to the east. Much of the coal is bright and hard, but there are frequently dull bands with a shaly fracture which resembles a very coaly bone. The appearance of these may be due in part to impurities, but is possibly also caused in part by less complete carbonization. There is little doubt that the coal is of Tertiary age, and the beds are presumably the stratigraphic equivalents of some of those to the east.

Section on west bank of Eska Creek, elevation 875 feet.

	Ft.	in.	Ft.	in.
Shale and sandstone			10	
Coal[c]	1	3		
Shale		1		
Coal[c]	1	4		
Shale		1		
Coal, bony	1	3	7	8½
Shale		½		
Coal, bony	1	1		
Shale		1		
Coal with some shale and bone	2	6		
Shale				6
Coaly shale			2	

Strike N. 30° E. (magnetic), dip 44° NW.

[a] Included in samples Nos. 13 and 14; see analyses, p. 27.
[b] Included in sample No. 17; see analysis, p. 28.
[c] Included in sample No. 18; see analysis, p. 28.

Section on west bank of Eska Creek, about 300 feet farther up.

	Ft.	in.
Shale roof.		
Coal [a]	3	3
Shale		3
Coal		11
Shale		5
Coal		6
Shale		6
Coal		4
Shale		1
Coal		9
Soft black shale.		
	7	0

Dip NW.

Section on Eska Creek, about 600 feet above lower section.

	Ft.	in.
Shale and sandstone.		
Coal	2	6
Dirty coal	1+	

Dip 32° SE.

Section in bluff on west bank of Eska Creek, elevation 1,030 feet.

	Ft.	in.	Ft.	in.
Sandstone			15	
Coal	2		2	
Shale			15	
Coal	3		3	
Shale			3	
Coal	3		3	
Concretionary shale			6	
Black shale			5	
Coaly shale			1	
Coal, shaly		6		
Coal		9		
Shale with some coal		8		
Coal	2	1		
Shale	1			
Coal	1	4	11	4
Shale	1			
Coal	1			
Shale	2			
Coal	1			
Shale			12	
Coal	1			
Shale	2		4	
Coal	1			
Shale			10	

Strike N. 40° W. (magnetic), dip 40° SW.

A fault cuts this bluff and the section was measured above it. Below it the strike is northeast and the dip southeast.

[a] Included in sample No. 19; see analysis, p. 28.

The following measurements were made on Tsadaka Creek:

Section of coal near upper end of Tsadaka Creek gorge, elevation 700 feet.

	Ft.	in.	Ft.	in.
Fissile black shale			1	
Carbonaceous shale				6
Sandstone				2
Coal		2		
Sandstone		1		
Bright coal[a]	2	4		
Shale		6		
Bright coal[a]	2		8	1
Dull coal[a]	1	2		
Shale		4		
Dull coal	1	6		
Shale			1	
Massive sandstone			6	

Strike N. 20° W., dip 24° NE.

Section on east bank of Tsadaka Creek, about 100 yards below upper cabin, elevation 780 feet.

	Ft.	in.	Ft.	in.
Coal with hard ferruginous inclusions	3		3	
Shale			2	
Coal (bright)[b]	4	6		
Shale		2		
Coal (bright and hard)[b]	7		12	8
Soft shaly coal	1			
Soft shale with abundant iron-ore concretions			80±	
Massive sandstone			10±	

Strike N. 50° E., dip 43° NW.

A westward extension of the coal is reported on Little Sushitna River, but that region was not visited by the writer. The coal is said to occur in thin beds and to be lignite, but it is not known whether it is a true lignite or a low-grade bituminous coal like that on Eska and Tsadaka creeks.

ADJACENT COAL FIELDS.

Coal is reported from numerous localities in the region surrounding that described in this report. The information regarding many of these is meager, but it nevertheless seems best to bring it together here.

There is an area of lignite at or near Point Campbell, at the juncture of Knik and Turnagain arms, which has been used to a limited extent as local domestic fuel. The coal seen by the writer had been picked up at the outcrop and was a lignite of rather poor quality. It may be that the coal from this bed would be better where not so badly weathered, or that there are more valuable seams in the vicinity.

Mendenhall states[c] that "along the upper course of Bubb Creek * * * thin coals may occasionally be seen interbedded with the shales and sandstones forming the stream bluffs." No further information in regard to them is given.

Coal in thin beds is reported from Hicks Creek, about 3 miles above its mouth, and as "float" near the headwaters of the Tazlina.[d]

An outcrop of coal on Chickaloon Creek, about 26 miles above the mouth of Boulder Creek, was reported by Sergeant Mathys, of Captain Glenn's expedition. It is described[e] as "a vein of coal running across the ridge, which was 4 feet in width and

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[a] Included in sample No. 20; see analysis, p. 28.
[b] Included in sample No. 21; see analysis, p. 28.
[c] Op. cit., p. 324.
[d] Glenn, Capt. E. F., Reports of Explorations in the Territory of Alaska, War Dept., Adjutant-General's Office, No. 25, 1899, p. 112.
[e] Mathys, Sergt. Frederick, Reports of Explorations in the Territory of Alaska, War Dept., Adjutant-General's Office, No. 25, 1899, p. 274.

apparently a very good quality of soft coal." This is of considerable importance as probably showing a recurrence of coal-bearing rocks not far north of the Matanuska Valley.

There appears to be a considerable area of coal or lignite in the Sushitna Valley, in the vicinity of the mouth of the Talkeetna. Some of the exposures were seen by Eldridge,[a] who describes them as follows:

> The third coal field along the main river, 4 to 10 miles above the Chulitna, appears in outcrops for a distance of 6 or 7 miles and is perhaps the exposed portion of an extensive area. The strata form bluffs 100 to 300 feet high, and consist of clays and sandstones—the former predominating—with coal seams from 6 inches to 6 feet thick. There are perhaps ten or fifteen coal beds exposed in the entire length of the outcrop. Their general dip is 5° to 10° SSE., with undulations. The thickness of the series exposed is perhaps 500 feet.

Other exposures in the same general district were described by Lieutenant Learned, who said:[b]

> As the party under my charge proceeded up the Sushitna River specimens of coal were found on the sand bars from time to time, but more plentifully as the forks were approached. On the way down the river an outcropping of coal was seen on the east fork of the Sushitna River, about 2 miles south of the fork. The vein could not be measured, but as near as could be determined it was about 6 feet thick and of a poor quality.
>
> Upon entering the Talkeetna River coal was seen on the bars and banks, and the same coal was found in the Chinaldna River. It was the main fuel used at the camp on the Chinaldna River for about two months. The coal found there was a brown lignite of about the same grade as the best found in the vicinity of Tyoonok. The vein was located first by Sergeant Yanert, and is noted on his map. It is about 6 miles above the mouth of the Chinaldna, at the base of a cut gravel bank about 100 feet high. When seen by Sergeant Yanert the water was clear and the vein could be traced across the river to the east bank. When I visited the vein the river was flooded and therefore very muddy. As near as could be determined by me the vein was 6 feet out of and fully as much more under the water, making it 12 feet thick, but Private Gamble, who had seen it in clear water, said it was at least 15 feet thick and perhaps much more, as it extended across the river, forming its bed, and there was no way of determining the thickness of that part forming the bed of the river. The vein is only slightly tilted, and comparatively easy to work if occasion should ever render it valuable. * * * All of the coal found, when consumed, gave a fair amount of heat, but left a large amount of ashes. * * * Sergeant Yanert reported that he found another large coal vein on the Chulitna River of about the same grade as the Tyoonok coal. It is doubtful if the coal found will ever have any commercial value, except such value as it possesses for fuel in the vicinity, and even that will be small, because of the timber found in the same localities. Enough was ascertained to show that there is plenty of coal of an inferior grade along the Sushitna River.

The Cook Inlet coal fields have already been described by various authors. All existing information was summarized in 1902 by Brooks,[c] who gave complete references to the earlier publications.

ANALYSES AND TESTS.

Chemical and calorimetric tests.—The samples collected by the writer were (with the exception of No. 3) all taken in a uniform manner. They were obtained by making a cut across a fresh face of the coal from roof to floor, cutting down only the coal which would probably be loaded and leaving out such impurities as could be separated in the ordinary practices of actual mining. They are thus supposed to represent the quality of the coal which would be mined from these seams. The parts of each seam which went into the sample are indicated in the local sections. No. 3 was taken from only the best parts of the seam (see p. 21) and impurities were rejected which could be separated in practice only by very careful treatment, such as in "screened and hand picked" coal, or possibly by some mechanical process or by washing. The object of this selection was to show, by a comparison of analyses Nos. 2 and 3, what could probably be gained in practice by such careful separation of impurities.

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[a] Eldridge, G. H., A reconnaissance in the Sushitna basin and adjacent territory in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 22.

[b] Learned, Lieut. H. G., Reports of explorations in the Territory of Alaska, War Dept., Adjutant-General's Office, No. 25, 1899, pp. 162-163.

[c] Brooks, A. H., The coal resources of Alaska: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 543-546.

Analyses and tests of Matanuska coals.

No. of sample.	Locality.	Thickness of coal seam in feet.	Moisture in air-dried sample.[a]	Total moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calories[b] per pound of coal.	Recalculated.		
										Fuel elements.		Fuel ratio.
										Volatile matter.	Fixed carbon.	
1	Between Boulder and Hicks creeks	38.0	(c)	2.55	7.08	84.32	6.05	0.57	7,613	7.75	92.25	11.90
2	Chickaloon Creek, tunnel No. 2	12.3	0.98	2.58	19.14	67.46	10.82	.57	.....	22.10	77.90	3.52
3	Chickaloon Creek, tunnel No. 2 (selected)	5.2	(c)	.90	19.60	74.60	4.90	.60	8,260	20.81	79.19	3.81
4	.....do	.....	(c)	1.06	12.76	78.96	6.28	.90	.....	13.91	86.09	6.19
5	Chickaloon Creek, tunnel No. 3	7.0	1.46	2.46	17.01	53.23	27.30	.84	.....	24.22	75.78	3.13
6	Chickaloon Creek, tunnel No. 5	7.9	1.00	2.90	17.47	56.15	23.48	.46	.....	23.73	76.27	3.21
	Average of analyses, 2–6	.....	.....	1.98	17.20	66.08	14.56	.67	.....	20.95	79.05	3.77
7	Matanuska River, south side, 3 miles above Chickaloon Creek	7.0	2.76	4.36	18.92	61.19	15.53	.37	.....	23.62	76.38	3.23
8	.....do	7.0	(c)	4.15	20.63	59.62	15.60	.34	.....	25.71	74.29	2.89
9	Coal Creek, ¾ mile above mouth	5.0	1.44	2.24	23.08	70.21	4.47	.50	.....	24.74	75.26	3.04
10	.....do	5.0	(c)	1.88	22.51	71.65	3.96	.44	.....	23.91	76.09	3.18
11	Coal Creek, ¾ mile above mouth	8.6	2.64	6.74	14.96	65.83	12.47	.44	6,649	18.52	81.48	4.40
12	.....do	8.6	(c)	5.83	18.24	63.03	12.90	.47	.....	22.44	77.56	3.46
	Average of analyses, 7–12	.....	.....	4.20	19.72	65.26	10.82	.42	.....	23.14	76.86	3.32
13	Kings Creek, west bank, upper bridge	9.9	1.13	2.93	21.85	63.09	12.13	.59	7,419	25.72	74.28	2.89
14	.....do	9.9	(c)	1.22	24.15	62.65	11.98	.52	.....	27.82	72.18	2.59
15	Kings Creek	.....	(c)	1.15	23.09	69.34	6.42	.89	.....	24.98	75.02	3.00
16	.....do	.....	(c)	.50	22.00	70.50	7.00	.....	.....	23.78	76.22	3.20
	Average of analyses, 13–16	.....	.....	1.45	22.77	66.40	9.38	.67	.....	25.57	74.43	2.91

[a] Determined by drying in the open air until weight becomes constant.
[b] A calorie is the amount of heat necessary to raise the temperature of 1 pound of water 1° C. It is equal to 1.8 British thermal units.
[c] Not determined.

Analyses and tests of Matanuska coals—Continued.

No. of sample.	Locality.	Thickness of coal seam in feet.	Moisture in air-dried sample.	Total moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calories per pound of coal.	Recalculated. Fuel elements. Volatile matter.	Recalculated. Fuel elements. Fixed carbon.	Recalculated. Fuel ratio.
17	Young Creek, 3 miles above trail	1.0	(a)	2.50	28.32	58.82	10.36	0.58	.....	32.50	67.50	2.08
	Average of analyses, 2-17	.....	.....	2.71	20.23	65.39	11.60	.57	.....	23.65	76.35	3.23
18	Eska Creek, 3 miles above trail	2.6	(a)	5.56	36.52	51.32	6.60	.42	.....	41.58	58.42	1.41
19	.....do.....	3.3	(a)	6.60	34.30	48.23	10.87	.41	6,299	41.56	58.44	1.41
	Average of analyses, 18-19	.....	.....	6.08	35.41	49.78	8.23	.42	.....	41.57	58.43	1.41
20	Tsadaka Creek, 4 miles above trail	6.0	(a)	4.03	34.84	49.31	11.82	.38	.....	41.40	58.60	1.42
21	Tsadaka Creek 4½ miles above trail	11.7	5.45	10.05	36.05	48.90	5.00	.25	.....	42.44	57.56	1.36
	Average of analyses, 20-21	.....	.....	7.04	35.45	49.10	8.41	.32	.....	41.92	58.08	1.39
	Average of analyses, 18-21	.....	.....	6.56	35.43	49.44	8.32	.37	.....	41.74	58.26	1.40

a Not determined.

1-3, 5-7, 9, 11, 13, 17-21. Sampled by G. C. Martin. Analyses by F. M. Stanton, U. S. Geol. Survey coal-testing plant, St. Louis, Mo.
8, 10, 12, and 14. Sampled by William Griffith and G. C. Martin. Analyses by A. S. McCreath, Harrisburg, Pa.
15. Sampled by George Jamme. Analysis by C. C. Borgardus, Seattle, Wash. Published in Bull. U. S. Geol. Survey No. 259, 1905, p. 170.
16. Sampled by Frank Watson. Analysis by William H. Stowell & Co., Seattle, Wash.

The samples which the writer collected were all analyzed by Mr. F. M. Stanton at the United States Geological Survey coal-testing plant at St. Louis, Mo. The methods of analysis are described in their reports.[a]

The other analyses were gathered from a variety of sources. Nos. 4, 8, 10, 12, and 14 are based on duplicates of samples taken by the writer. The others are of varied

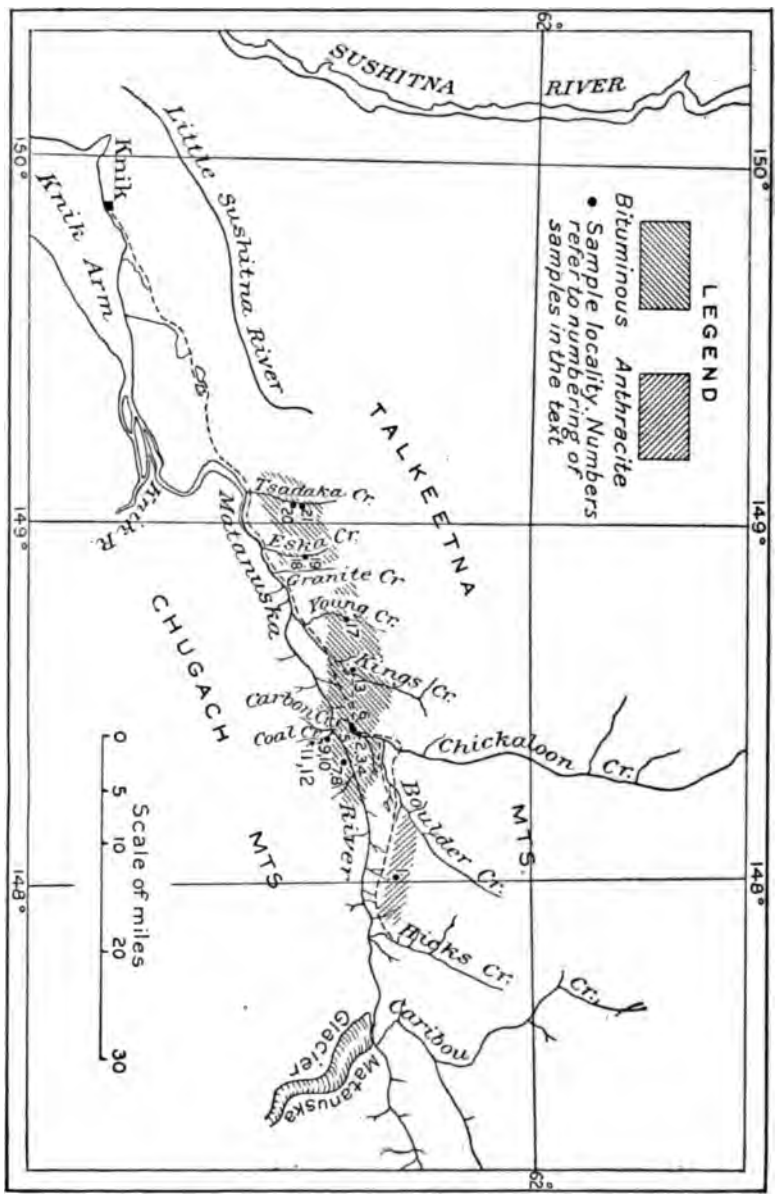

Fig. 4.—Sketch map of Matanuska Valley showing coal areas and localities from which coal samples were taken.

character, some being fair representations of the seams and some random selections of the best coal. The localities from which the samples came are indicated in fig. 4.

[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Bull. U. S. Geol. Survey No. 261, 1905, pp. 30-31. Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Prof. Paper U. S. Geol. Survey No. 48, 1906, pp. 174-192.

The anthracite coal is represented by a single analysis (No. 1), which shows it (so far as this one outcrop is concerned) to compare not unfavorably with some of the Pennsylvania anthracite.

Comparison of Matanuska and Pennsylvania anthracite.

Coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
Matanuska	2.55	7.08	84.32	6.05	0.57	11.91
Pennsylvania (average of 9)[a]	3.39	3.81	83.79	8.42	.59	22.33

[a] Ashburner, C. A., Ann. Rept. Geol. Survey Pennsylvania, 1885, p. 313.

The coals represented by analyses 2 to 17 are near the border line between semi-bituminous steam coals (as the name is generally used in the trade, but not according to Frazer's definition)[a] and bituminous coking coals. They are rather high in ash, but are otherwise of good quality. Analyses 5 and 6 bring the average abnormally high, but even aside from these most of the seams are so impure that mechanical separators or washing should be used to remove part of the impurities. The purer of these coals correspond very closely to the Crows Nest Pass (British Columbia) coal,[b] which is the standard coking coal of western North America, and approximately to some of the coking coal of the East.

The lower-grade bituminous coal on Eska and Tsadaka creeks, which the analyses show to be intermediate between first-class bituminous coal and the lignite coals, should probably be called bituminous rather than lignite, as it is usually called in the region. It is of about the same composition as the Franklyn, Black Diamond, and Renton (Washington) coal. It will probably not make good coke, but should serve well under stationary boilers, and possibly as a locomotive fuel and for other local uses. It should be especially well adapted to the generation of power by the use of producer gas in a gas engine.

Coking qualities.—A rough test of the coking qualities of the coal from tunnel No. 2 on Chickaloon Creek (see p. 21) was made during the summer of 1905, by coking a large pile of coal under a covering of stones and dirt. The resulting coke was hard and firm and had a good ring and a good texture. The test showed conclusively that a satisfactory grade of coke can be produced.

MINING CONDITIONS.

There are no serious difficulties in the way of mining these coals. The dips are so steep (10° to 60° on the anthracite, 18° to 85° in the east end of the bituminous area, and 20° to 44° in the west end of the bituminous area) that some method of stoping will have to be used. Miners who are accustomed to the steep dips in some of the coal mines of Washington and British Columbia will have no difficulty in this field. Drifts can be run from the level of some of the main streams and enough coal found above drainage to supply the mines for some time. It will ultimately be necessary to resort to slope or shaft mining. These methods (or tunnels across the measures from the upper floor of the Matanuska Valley) will probably have to be used on the anthracite very soon. But no operations should be undertaken in the anthracite area without thoroughly investigating the amount of workable coal, both by carefully exploring the surrounding country in search of outcrops and by testing the thickness and continuity of the seams by boring or other underground work. There is an abundant local supply of wood for building and mine timbering.

[a] Rept. Geol. Survey Pennsylvania, vol. MM, 1879, pp. 144-145.
[b] Martin, G. C., Markets for Alaska coal: Bull. U. S. Geol. Survey No. 284, 1906, p. 29.

It will be necessary to wash or otherwise clean the coal from some of the seams. The percentage of ash can be reduced, by washing, from 10, 12, 15, 23, and 27 per cent to less than half and probably in some cases to a quarter of these figures. The tests at the coal-testing plant of the United States Geological Survey showed instances[a] where the percentage of ash was reduced as follows:

Results of washing tests.

Percentage of ash in—	
Raw coal.	Washed coal.
22.44	9.42
13.40	7.16
28.39	7.59
13.81	6.22
10.59	5.86
9.99	6.33
7.75	7.49
25.05	8.14
16.00	10.25
15.22	10.28

It is probable that with a plant adapted especially to some particular coal and with employees experienced in handling that coal even better results could be obtained.

TRANSPORTATION AND MARKETS.

None of this coal can be used until a railroad is built to tide water. The Alaska Central Railway, now building from Seward to the interior, is expected to tap this coal field. The coal may then find a market for use as motive power on the railroad; for fuel in the towns and mines which may grow up along the line of the railroad and at its termini; for coke at the possible Alaska smelters; for bunker coal on the ocean and river steamers touching at the termini of the railroad, and for export. The question of markets and of competition with other fuels has been discussed in detail in another paper.[b]

GOLD.

The terrace and stream gravels along the Matanuska are reported to carry small amounts of gold, but no locality has yet been found which is rich enough to be worked. It is entirely possible that placer deposits will be found in this region, but they will probably be on the tributaries rather than in the main Matanuska Valley or in the broad gravel sheet at its mouth. A placer deposit is now being worked in the mountains north of Little Sushitna River with considerable reputed success. The geologic conditions in the vicinity are not known. The Turnagain Arm placers[c], which have long been successfully worked, are not far south of the Matanuska Valley. It is quite possible that conditions similar to those at these localities will be found somewhere adjacent to the Matanuska.

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[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: Bull. U. S. Geol. Survey No. 261, 1905, pp. 60–78.

[b] Martin, G. C., Markets for Alaska coal: Bull. U. S. Geol. Survey No. 284, 1906, pp. 18–29.

[c] Moffit, F. H., The gold placers of Turnagain Arm: Bull. U. S. Geol. Survey No. 259, 1905, pp. 90–99; Mineral resources of the Kenai Peninsula, Alaska: Bull. U. S. Geol. Survey No. 277, 1906, pp. 7–62.

Metalliferous veins carrying both gold and copper are reported in the mountains bordering the Matanuska Valley. Very little is known regarding either these reputed discoveries or the geology of the localities in which they are supposed to have been made.

IRON ORE.

The shales which contain the coal in the region between Tsadaka and Chickaloon creeks contain also numerous beds of iron-carbonate concretions. Several of these are shown in the sections on Chickaloon Creek recorded on pages 12 and 13. The concretions vary in diameter from a fraction of an inch to several feet. They are often so abundant as to make solid beds of the ore. These beds are from a few inches to 2 or 3 feet in thickness.

Analysis of ferrous-carbonate concretion from Tsadaka Creek.

Total iron	19.6
Insoluble in HCl	25.5

The bed from which this particular sample came is too poor in iron to be of value. It is possible that further search will bring to light beds which are thick enough and high enough in iron to be worked on a small scale.

Another specimen from Tsadaka Creek which had apparently been partially reduced from contact with a burning coal bed contained 70 per cent Fe_3O_4 and 20 per cent Fe_2O_3, or a total of 63.8 per cent iron. This sample of ore is of good quality, but the amount is far too small to be of value. Its chief interest is in its origin. One of the beds of iron carbonate had been brought in contact with a coal seam by faulting. In some way, probably from a forest fire, the coal caught fire, with not only the usual result of baking the overlying shales but also that of reducing the iron from the form of carbonate to that indicated in the analysis.

APPENDIX.

The references given below will doubtless be useful to anyone who wishes to make comparisons of this coal with that in other parts of Alaska.

LIST OF PAPERS, BY MEMBERS OF THE UNITED STATES GEOLOGICAL SURVEY, ON COAL, LIGNITE, AND PETROLEUM OF ALASKA.

BROOKS, A. H. Coal resources of Alaska. Twenty-second Ann. Rept., U. S. Geol. Survey, pt. 3, 1902, pp. 515–571.

——— The outlook for coal mining in Alaska.[a] Trans. Am. Inst. Min. Eng., bimonthly bulletin No. 4, 1905, pp. 683–702.

——— The production of coal in 1904:[a] Alaska. Mineral Resources for 1904, U. S. Geol. Survey, 1905, pp. 112–144 (of separate), 452–454 (of complete volume).

COLLIER, A. J. Coal resources of the Yukon basin, Alaska. Bull. U. S. Geol. Survey No. 213, 1903, pp. 276–283.

——— The coal resources of the Yukon, Alaska. Bull. U. S. Geol. Survey No. 218, 1903, 71 pp.

——— The coal fields of Cape Lisburne, Alaska. Am. Geol., vol. 34, 1904, pp. 401–402.

——— Coal fields of the Cape Lisburne region. Bull. U. S. Geol. Survey No. 259, 1905, pp. 172–184.

——— Geology and coal resources of the Cape Lisburne region. Bull. U. S. Geol. Survey No. 278, 1906.

DALL, W. H. Report on the coal and lignite in Alaska. Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 763–908.

MARTIN, G. C. Petroleum fields of Alaska and the Bering River coal fields. Bull. U. S. Geol. Survey No. 225, 1904, pp. 365–382.

——— The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits. Bull. U. S. Geol. Survey No. 250, 1906, 64 pp.

——— Notes on the petroleum fields of Alaska. Bull. U. S. Geol. Survey No. 259, 1905, pp. 128–139.

——— Bering River coal field, Alaska. Bull. U. S. Geol. Survey No. 259, 1905, pp. 140–150.

——— Markets for Alaska coal.[a] Bull. U. S Geol. Survey No. 284, 1906, pp. 18–29.

——— The distribution and character of the Bering River coal. Bull. U. S. Geol. Survey No. 284, 1906, pp. 65–77.

——— Preliminary statement on the Matanuska coal fields.[a] Bull. U. S. Geol. Survey No. 284, 1906, pp. 88–100.

STONE, R. W. Coal resources of southwestern Alaska.[a] Bull. U. S. Geol. Survey No. 259, 1905, pp. 151–171.

——— Coal fields of the Kachemak Bay region. Bull. U. S. Geol. Survey No. 277, 1906, pp. 53–73.

LIST OF PAPERS, BY MEMBERS OF THE U. S. GEOLOGICAL SURVEY, CONTAINING REFERENCES TO THE COAL, LIGNITE, AND PETROLEUM OF ALASKA.

BARNARD, E. C. Report of the Fortymile expedition. Maps and descriptions of routes of exploration in Alaska in 1898; special publication of the U. S. Geol. Survey, 1899, p. 81.

DALL, W. H., and HARRIS, G. D. The Neocene of North America. Bull. U. S. Geol. Survey No. 84, 1892, pp. 232–268.

ELDRIDGE, G. H. The extreme southeastern coast. The coast from Lynn Canal to Prince William Sound, Alaska. Maps and descriptions of routes of exploration in Alaska in 1898; special publication of the U. S. Geol. Survey, 1899, pp. 101–104.

——— A reconnaissance in the Sushitna basin and adjacent territory, Alaska, in 1898. Twentieth Ann. Rep. U. S. Geol. Survey, pt. 7, pp. 7–29. 1900.

——— and MULDROW, ROBERT. Report of the Sushitna expedition. Maps and descriptions of routes of exploration in Alaska in 1898; special publication of the U. S. Geol. Survey, 1899, pp. 22–25.

EMMONS, S. F. Alaska and its mineral resources. Nat. Geog. Mag., vol. 9, 1898, pp. 170–172.

——— Map of Alaska, showing known gold-bearing rocks, with descriptive text containing sketches of the geography, geology, and gold deposits and routes to the gold fields. Special publication of the U. S. Geol. Survey, 1898, pp. 39–44.

[a] Contains references to the Matanuska coal.

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[Bulletin No. 289.]

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SEPTEMBER, 1906. WASHINGTON, D. C.

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PAPERS ON ALASKA IN PREPARATION.

BROOKS, A. H. An exploration in the Mount McKinley region.

COLLIER, A. J., HESS, F. L., and BROOKS, A. H. The gold placers of a part of the Seward Peninsula, Alaska.

MARTIN, G. C. Geology of the Controller Bay coal field, Alaska.

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The following maps are for sale at 5 cents a copy, or $3 per hundred:

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The following maps are included as illustrations of published reports, but have not been issued separately. They can be obtained only by securing the report.

Alaska, topographic map of; scale, 1:2500000. Preliminary edition. Contained in "The geography and geology of Alaska, a summary of existing knowledge, etc." Prof. Paper No. 45. R. U. Goode.

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Cook Inlet, head of, to the Tanana via Matanuska and Delta rivers, also part of Kenai Peninsula; scale, 1:625000. Contained in "A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898." Twentieth Ann. Rept., pt. 7, 1900, pp. 265–340. W. C. Mendenhall.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PRELIMINARY REPORT

ON THE

OPERATIONS OF THE FUEL-TESTING PLANT OF THE UNITED STATES GEOLOGICAL SURVEY AT ST. LOUIS, MO., 1905

JOSEPH A. HOLMES

IN CHARGE

WASHINGTON

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INTRODUCTION.

By J. A. Holmes.

ORGANIZATION.

The authority for continuing at St. Louis, Mo., the investigation of the fuel values and possibilities of the coals and lignites of the United States, inaugurated at the Louisiana Purchase Exposition in 1904, is contained in the act of Congress making appropriation for the sundry civil expenses of the Government for the fiscal year ending June 30, 1906. This act carried an item of $202,000 "for the analyzing and testing of the coals, lignites, and other fuel substances of the United States in order to determine their fuel values, and so forth, under the supervision of the Director of the United States Geological Survey."

This appropriation became available within a few days subsequent to the passage of the bill (March 3, 1905) and the investigations were resumed May 1, following. The appropriation covers the period from May 1, 1905, to July 1, 1906, but the present preliminary report covers the period from May 1 to December 31, 1905. During this period the work has been carefully conducted and the methods of procedure improved, as compared with those used during the Exposition period, but the scope of the work has, as heretofore, been largely limited to a series of comparative tests, made as nearly as possible under similar conditions, of the samples of bituminous coal and lignite collected from the different coal fields of the United States.

LOCATION AND BUILDINGS.

The plant in which these investigations are carried on has remained at its original location in Forest Park, in the city of St. Louis, Mo., the grounds formerly occupied by the Exposition.

The preliminary installation of the plant included a chemical laboratory, a boiler and engine house, a storage and washery building, two buildings for briquetting purposes, a drying plant, and three full-size beehive coke ovens, all of which, with the exception of the building containing the chemical laboratory, were, as previously reported, furnished at the expense of the United States Government. The chemical laboratory, during the Exposition period, was installed in a building occupied during the Exposition as a metal pavilion, but now utilized for cement-testing investigations. To the group of fuel-testing buildings have been added two others left from the Exposition—one a foundry building, 100 by 125 feet, for coking investigations, into which the chemical laboratory has been transferred; the other a building now used for offices which was formerly the State building of South Dakota. The foundry building was supplied by the Exposition company without charge; the office building, a 12-room house about 150 yards from the boiler plant, was leased from private parties, and a small monthly rental is paid.

The facilities at the plant for the storage of coal received for testing purposes have been largely increased. In the original washery building there were four 35-ton and two 17-ton bins. To these have been added five 35-ton bins on the northwest side of the washery building, immediately over the railway track; four 25-ton bins on the northwest side of the boiler room, and three 50-ton auxiliary bins on the ground adjacent to the coke ovens. Two 5-ton bins have been added on the gas-producer platform. These have brought the storage capacity from 175 tons in 1904 up to 610 tons in 1905.

EQUIPMENT.

The major part of the equipment of the plant during the current year has remained much as it was during 1904, though a number of additions have been made. In the list given below, the equipment mentioned in the reports for 1904 [a] is included for the convenience of those who may not have access to those reports; the articles which have been subsequently added are marked with an *. The new equipment is described more fully in the accompanying papers relative to the work of each division. The following list contains the more important items for all the divisions:

Two Heine water-tube boilers, 210 horsepower each, contributed by the Heine Safety Boiler Company, of New York and St. Louis.

One Allis Corliss engine, contributed by the Allis-Chalmers Company, of New York and Chicago. The Corliss engine was belt-connected to a Bullock electric generator contributed by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio.

One Frost fire-tube boiler of 100 horsepower and a 50-horsepower slide-valve engine, both contributed by the Frost Engine Company, of Galesburg, Ill.

Two Taylor gas producers (one 7-foot producer and one 8-foot producer with inside diameter reduced to 7 feet by fire brick), with complete outfit for scrubbing and purifying gas, supplied by R. D. Wood & Co., of Philadelphia. These producers are installed to operate alternately with one tar extractor and one engine.

One Westinghouse gas engine of 235 brake horsepower, supplied by the Westinghouse Machine Company, of Pittsburg, and operated by the gas made in the Taylor producers.

One Westinghouse electric generator, belt-connected to the gas engine, supplied by the Westinghouse Electric and Manufacturing Company, of Pittsburg.

Seven motors of different horsepower, required for the operation of the different portions of the plant, supplied by the Westinghouse Electric and Manufacturing Company.

One Bartlett direct-heat rotating drier for driving out the moisture from washed coals and lignites whose moisture contents were too high to permit successful briquetting, contributed by the C. O. Bartlett & Snow Company, of Cleveland, Ohio.

One briquetting plant supplied by William Johnson & Sons, of Leeds, England.

A washing plant equipped with two Luhrig jigs,* constructed at the plant, and a modified Stewart jig, supplied by the Link Belt Machinery Company, of Chicago.

A battery of three full-size beehive coke ovens, constructed of red brick and lined with fire brick, contributed by the Laclede Fire Brick Manufacturing Company, of St. Louis.

One 7-ton larry * for use in charging the coke oven, contributed by the Frick Coke Company, of Pittsburg.

One Climax gasoline gas machine,* about 1,000 candlepower, supplied by the Federal Gas Company, of St. Louis, for use in the chemical laboratory (this being rendered necessary by the cutting off of the city gas supply from these grounds after the Exposition closed).

One McClave rocking grate.*

One forced-draft outfit,* consisting of a blower and a direct-connected steam engine, supplied by the B. F. Sturtevant Company.

The foregoing list includes all that might properly be considered testing machinery, but the following additional incidental equipment and material were contributed by the firms mentioned:

One Williams crusher, by the Williams patent Crusher and Pulverizer Company, of St. Louis.

A complete outfit of belt-conveying apparatus, contributed and installed by the Robins Conveying Belt Company, of New York.

A 30-inch Jeffrey conveying belt * for delivery of coal to the gas producer direct from the car or from the ground bins.

Scales, by Fairbanks, Morse & Co., of New York and Chicago.

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[a] Bull. U. S. Geol. Survey No. 261, 1905, p. 12; Prof. Paper U. S. Geol. Survey No. 48, 1906, p. 25.

Smoke-preventing device, automatic steam jet, by H. H. Hughes, of St. Louis.

Thermometers and pressure gages, by the Hohmann & Maurer Manufacturing Company, of Rochester, N. Y.

One Crosby recording steam gage.*

Draft gages, by the Appliance Manufacturing Company, of Chicago.

One Bristol recording draft gage.*

Feed-water heater and pump, by the Stillwell-Bierce Smith-Vaile Company, of Cincinnati.

Le Chatelier pyrometers, by Charles Engelhard, of New York.

One Wann optical pyrometer.

Engine indicators and attachments, by the Ashcroft Manufacturing Company, of New York, and the Crosby Steam Gage and Valve Company, of Chicago.

Metallic piston packing, by the Steel Mill Packing Company, of Detroit.

Burroughs adding machine, by the American Arithmometer Company, of St. Louis.

Oil filter, by the Famous Filter Company, of St. Louis.

Gas meters, by the Pittsburg Meter Company, of Pittsburg.

Dumping car and bucket conveyors, by the Austin Manufacturing Company, of Chicago.

Centrifugal pump, by Henion & Hubbell, of Chicago.

Calculating machine, by the Keuffel & Esser Company, of New York.

Power crusher and automatic sampler for preparing samples for the chemical laboratory, by the F. W. Braun Company, of Los Angeles, Cal.

The plans for the buildings and their arrangement were prepared by the Roberts & Shaefer Company, engineers, of Chicago.

The boiler room was thoroughly equipped with standardized apparatus for weighing coal and water, for determining the force of the draft, for ascertaining the temperatures in the different parts of the furnace, and for analyzing the flue gases. The gas producer and gas engines were also provided with apparatus for ascertaining temperatures, for collecting samples of the gas as produced, and for determining the horsepower developed in the gas engine. The electrical horsepower developed by both the steam engine and the gas engine was ascertained by twenty-minute readings of voltmeters and ammeters, and the electrical horsepower developed per pound of fuel consumed by the two different methods was thus accurately determined and recorded.

The chemical laboratory was equipped with every necessary apparatus and chemical material for making proximate and ultimate analyses and for determining the calorific value of the coal. This value was obtained by a Mahler bomb calorimeter, the observations being made in a room especially set aside for this purpose. To this equipment was added during 1905 one Abbe ball mill for pulverizing; a 48-inch square steel-top table for quartering samples; one large drying oven for air-drying samples, and two moisture ovens for determining moisture at 105° C. (these ovens especially designed by Prof. N. W. Lord); an additional bomb and two Galaz thermometers for the Mahler bomb calorimeter equipment, and for general use in the laboratory two Troemner balances, one torsion balance, and a Climax gas machine (referred to above).

The railroad companies entering St. Louis or having coal resources along their lines have cooperated most heartily with the officers in charge of this work.

PERSONNEL.

Many of the experts who were in charge of the investigations during 1904 have been continued in charge of the tests now being conducted. A number of additional assistants however, have been necessary in order that more rapid and efficient progress might be made with the work. In addition to the skill and services of the experts regularly employed, the operations of the plant have been aided by the hearty cooperation and ready and helpful advice of leading engineers resident in many parts of the country. A general committee, appointed by the Director of the Geological Survey, on the investigation of coal and other fuels is composed of Messrs. C. W. Hayes, J. A. Holmes, E. W. Parker, and M. R. Campbell.

The names of the experts and assistants employed in connection with the several divisions of the testing work are presented in subjoined reports covering these tests. The following is a list of those in charge of the several divisions and the assistants having special assignments:

J. A. Holmes, fuel expert in charge.

N. W. Lord (University of Ohio, Columbus), in charge of chemical work.

L. P. Breckenridge (University of Illinois, Urbana), engineer in charge of steaming tests.

R. H. Fernald (Washington University, St. Louis), engineer in charge of producer-gas tests.

C. T. Malcomson, mechanical engineer, in charge of general work at the plant.

A. W. Belden, in charge of coking tests.

W. T. Ray, assistant engineer, in charge of steaming tests.

John D. Wick, in charge of washing tests.

John A. Laird, assistant engineer, operating gas producers.

J. P. Quam, engineer, in charge of gas engine.

E. E. Somermeier, chemist, in charge of laboratory.

F. M. Stanton, head chemist.

Joseph Underwood, electrician.

The collection of the samples of coal has been under the supervision of Mr. E. W. Parker, of the Geological Survey. The work of collecting the samples has been done mainly and most efficiently by Messrs. J. S. Burrows, chief inspector; and J. W. Groves and W. J. Von Borries, inspectors. The methods followed in the collection and shipment of these samples are fully described elsewhere (pp. 17–18).

NATURE AND RESULTS OF THE INVESTIGATIONS.

The principal branches of the work carried on include (1) taking samples of coal of various mines by inspectors employed by the Geological Survey for this purpose; (2) making proximate and ultimate chemical analyses of these samples; (3) washing tests, to determine the possibility of improving the quality of the coal shipped by carloads from mines inspected; (4) coking tests, to determine the possibility of making coke or of improving the coking practice with a view to betterment in the quality of the coke made from these coals; (5) gas-producer tests, to determine the efficiency with which each coal can be used in this manner for power production; (6) steaming tests, to determine the fuel value of such coal in the ordinary steam boilers; (7) and briquetting tests, to determine the extent to which the fines or slack coals can be economically made into briquettes.

The results of these investigations will be discussed more at length in the later and more complete report. For the purposes of this preliminary report the following brief statement will suffice:

The carefully made analyses of these representative coals and lignites are giving to the engineers of the country data of great value, not only because this work is done with care, but also because the complete history of every such sample is indicated and the record is authentic and reliable. Up to December 31, 1905, more than 1,600 such chemical analyses have been made, involving more than 7,000 chemical determinations.

The following tests have also been made:

In the gas producer and gas engine, 85 tests, each extending over two or three days, of coals, lignites, and peats from 18 States.

In the steam boilers, 283 tests, each of from nine to eleven hours' duration, of 170 different coals from 18 States.

In the coke ovens, 110 tests, each of forty-eight to seventy-two hours' duration, of 95 coals from 16 States. Of these coals a large portion have heretofore been considered as noncoking coals.

In the washery plant it has been shown how the quality of 43 coals from 13 States and several samples of coke breeze could be improved by washing, at a nominal cost of from 3 to 10 cents per ton.

In the briquetting plant a number of new possible binding materials for coke briquettes have been investigated, and a few of these have proved sufficiently satisfactory to warrant further investigation as to their more extended use, at a probable cost considerably less than that of coal-tar pitch, which is ordinarily used for briquetting operations. A number of lignites, representing both the extreme Northwest and Southwest, have been briquetted under high pressure without the use of binding materials, and it has been shown that the cost of briquetting such materials should not exceed 50 cents per ton. Furthermore, it has been shown that in the use of certain briquetted coals for railroad and domestic purposes the increase in the efficiency of the coals used in the briquetted form is more than sufficient to cover the cost of the briquetting operations.

The producer-gas investigations have shown the suitability of bituminous coals, lignites, and peats for power purposes in the gas producer and the gas engine. While there remain difficulties in the way of the general introduction of this new source of power, yet the results of these investigations have already contributed in an important degree toward the overcoming of these difficulties and are serving as a basis of plans for new power developments in many parts of the country. Already 14 or more different companies are reported to be making producers for power purposes and others are endeavoring to perfect new designs. It may be added that at two of our great steel plants blast-furnace gas engines have been introduced for power purposes, and a dozen companies are now either manufacturing or working on plans for the manufacture of gas engines.

The advances made in simplifying and handling the gas-producer equipment at the St. Louis plant have so increased its efficiency that the average bituminous coals recently tested have yielded in it 2.6 times the amount of power they have given under steam boilers of equivalent capacity (210 horsepower), and in several cases this difference in favor of the gas power has been considerably greater—as high as three to one.

The development of the steam boiler and engine has required more than two hundred years, for the reason that along its path there was but little record of accurate data to serve as a basis of invention. It is confidently hoped that the information now being secured and assembled by the Survey will be the means of stimulating more rapid improvements and higher efficiencies in the use of fuels along several lines, and particularly of demonstrating the great practical possibilities of power developed with the gas producer and engine.

In connection with the large beds of lignite found in many of the Western States, the present investigations have been and will continue to be of much value in showing how these lignites may be used to advantage for power purposes, either in their natural condition, in gas producers and gas engines, or briquetted and then used under ordinary boilers, in gas producers, or in ordinary domestic stoves and furnaces.

These investigations, in addition to demonstrating how many of the so-called noncoking coals of the United States may be coked by exercising increased care either in the construction or in the operation of the ovens, have also shown how the quality of certain of these cokes may be improved by adding pitch or other hydrocarbons to the coal before being charged into the oven.

A not unimportant result of this work is educational, through (1) the awakening of the coal producers of the country to a more careful study of their coals and of possible methods of improvement in quality by washing, etc., and (2) the recognition by manufacturers and other coal consumers of the need of using their fuels more efficiently, and of purchasing them on a basis which indicates their true heating value, rather than on some general and indefinite trade name or classification, or at the "lowest price."

During the remainder of the present fiscal year (to June 30, 1906) the work of the fuel-testing plant will be largely confined to comparative tests of the fuel efficiencies of coals and lignites collected from different coal fields. But if provision is made for continuing the investigations beyond this period, there are a number of important fuel problems that await investigation and that should be investigated by the Government, not only because of their importance but because of the further fact that the solution of these problems has

to do with the supplies of power, heat, and light and with metallurgical industries in every part of the country.

Some of the more important of these fuel problems are outlined in the following paragraphs:

SOME PROBLEMS NEEDING INVESTIGATION IN THE UTILIZATION OF AMERICAN FUELS.[a]

FUELS FOR GENERAL AND METALLURGICAL PURPOSES.

(1) The investigation of coal dust and coal gas in relation to fires and explosives in coal mines and elsewhere.

(2) An investigation of the nature and extent of the deterioration or other changes of different coals when mined and stored under different conditions, as affecting (*a*) their efficiencies when used in boilers or gas producers or when used for domestic purposes; (*b*) their value for coking; (*c*) their liability to spontaneous combustion.

(3) The development of quicker and cheaper methods of testing coals, lignites, and other fuels, based on a knowledge of their chemical and physical characteristics.

(4) The establishment of an equitable basis for the sale and purchase of coal and other fuels, embodying a statement of their heat units and chemical and physical properties.

(5) The determination of the chemical and physical properties and fuel values of coals, lignites, and peats from such fields as have not yet been fully examined, or from new deposits that are being or may be opened up; also of the comparative values for fuel and power purposes of different coals, lignites, peats, and other substances.

(6) The development of briquetting and other methods for utilizing most efficiently slack or fine coals.

(7) The development of washing and other methods of improving the quality of low-grade coals for different uses.

(8) An investigation of the advantages of sizing coals for different uses, under different conditions, as compared with the use of run-of-mine coal.

(9) Investigations of coals in their relation to metallurgical work; of conditions under which the so-called noncoking coals can be made into coke by mixing different coals, by mixing other materials with the coals, or by other methods; of the relative value of cokes made in different ovens and under different conditions; of the most economical methods of making and using gases for metallurgical purposes.

(10) An investigation of the extent to which valuable by-products can be manufactured from the different American coals.

FUELS FOR BOILER PURPOSES.

A study of conditions under which different coals may be most economically burned under steam boilers, including the laws of combustion and smoke prevention:

(1) By variation of furnace conditions, as to grates, baffling, draft, rate of combustion, temperature, etc.

(2) By variations in character of the coal, as to sizes, etc., rate and regularity of firing, condition of the coal, etc.

(3) The effect of distribution and composition of ash in different coals, as to their economical burning.

(4) Reduction in the ash by washing the coal and other methods of lessening or avoiding the slagging of the ash on grate bars.

FUELS USED IN GAS PRODUCERS.

(1) The conditions under which different bituminous coals, lignites, and peats may be most efficiently used in gas producers.

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[a] Reproduced largely from Senate Doc. 214, 59th Congress, 1st sess., 1906.

(2) The separation of the tar and other by-products from the gases made in the producer and the commercial recovery of these by-products, or the fixing of the tar and other hydrocarbons as available gases for power purposes.

(3) The use of slack coals in the gas producer and the value of the sizing of lump coals for producer purposes.

(4) Utilization of blast-furnace gases and gases from coke ovens for power purposes.

DETAILED REPORTS OF TESTS.

Reports in detail of the results of the various tests described are printed on pages 53–233. It will be noted that the form and order in which the various test tables are arranged differ from those used in the reports on the fuel tests made during 1904.[a] In the present report the test records are grouped together under the respective coal samples and the samples are presented by States in alphabetical order. That this method of publication is an improvement will be apparent.

ANALYSES OF ALASKA COAL.

By way of cooperation with the Alaska division of the United States Geological Survey the laboratory of the fuel-testing plant at St. Louis analyzed 34 coals, samples of which were collected in the Bering and Matanuska River coal fields by Mr. G. C. Martin, one of the assistant geologists of the Survey. These analyses are to be found on pages 230–231 of this report.

INVESTIGATION OF PEAT.

Arrangements are being made for an examination of the nature and fuel value of peat from a number of localities in the different States. Prior to the writing of this report peat from but one locality (Massachusetts) has been tested through the producer and gas engine. The results of this test are given on page 134. The peat was collected, cut into small fragments, pressed into crude bricks approximately 3 by 6 by 1½ inches in size, and the moisture reduced, by air drying, from 85 to 45 or 50 per cent. In this form the peat was fed into the producer at the rate of 600 to 750 pounds per hour. The results of the test were eminently satisfactory. The peat burned freely, evenly, and completely. The gas had a fuel efficiency of 166 British thermal units per cubic foot of gas, as compared with 142 to 159 British thermal units per cubic foot of gas made from bituminous coal. The engine was run continuously during this test under full load. This same peat, cut into small fragments, but in a loose and wet condition (containing 80 to 85 per cent of moisture), did not burn satisfactorily in the producer, and attempts to dry this loose peat in the Bartlett direct-heat rotating dryer were unsatisfactory, owing in part, probably, to lack of time for readjusting the equipment to suit the unusual conditions imposed on it in handling the peat.

Shipments of peat from a number of other localities will be tested during 1906 and efforts will be made to develop better facilities for handling the unbriquetted material.

LITERATURE RELATING TO PEAT AND ITS UTILIZATION.

The following list will be found to include a number of articles of interest on the character and extent of peat deposits and the methods through which they are utilized in different countries. In a subsequent and more elaborate report on this subject the list of articles will doubtless be enlarged and descriptive notes will be added.

1816.

Cook, G. H., Geology of New Jersey, p. 481.

1835.

Hitchcock, C. H., Reports on geology of Massachusetts.

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[a] Bull. U. S. Geol. Survey No. 261, 1905; Prof. Paper U. S. Geol. Survey No. 48, 1906.

1841.

Hitchcock, C. H., Reports on geology of Massachusetts.

1842.

Dana, S. L., Muck manual. Lowell.

1851.

Brande, W. T., On peat and its products: Roy. Inst. Proc., pp. 109–111; also Am. Jour. Sci., 2d ser., vol. 11, p. 440.

1853.

Michigan Agric. Rept., Peat in Wayne County, p. 302.

1855.

Michigan Agric. Rept., Peat in Wayne County, p. 367.

1856.

Hitchcock, C. H., Reports on geology of Massachusetts.

1859.

Vogel, A., Der Torf, seine Natur und Bedeutung, Braunschweig.

1861.

Geology of Vermont, vol. 1, p. 174.

1862.

Senft, F., Humus, Marshen, Torf, und Limonit-Bildungen, Leipzig.

1866.

Illinois Geol. Survey, vol. 1.
Johnson, S. W., Peat and its Uses. New York.

1867.

Leavitt, T. H., Facts about Peat, Boston.

1868.

Illinois Geol. Survey, vol. 3.

1870.

Illinois Geol. Survey, vol. 4.
White, C. A., Geology of Iowa, vol. 2, pp. 275–288.

1872.

Lesquereux, L., Origin of coal: Hayden's Survey.

1873.

Geology of Ohio, vol. 1, pp. 221, 509, 571.
Illinois Geol. Survey, vol. 5.
Minnesota Geol. and Nat. Hist. Survey, Second Ann. Rept.

1874.

Trans. Wisconsin State Agric. Soc. 1874–75, pp. 75–92.
Geology of Ohio, vol. 2, p. 222.

1875.

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1877.

Geology of Wisconsin, vol. 2, pp. 240–246.

1878.

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Hitchcock, C. H., Reports on geology of New Hampshire, vol. 3.

1881.

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1884.

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1885.

Lesquereux, L., Origin of coal: Ann. Rept. Pennsylvania Geol. Survey, p. 109.

1887.

Roth, J., Alg. Chem. and Phys. Geol., vol. 2, p. 639.

1889.

Hirschbold, ——, Ueber Torfindustrie: Bayerisches Industrie und Gewerbeblatt, vol. 21, p. 59.

1890.

Shaler, N. S., Fresh-water morasses of the United States: Tenth Ann. Rept. U. S. Geol. Survey, pp. 255–339.

1891.

Ekelund, ——, Comprimirte Torfkohle: Oesterreichische Zeitschrift für Berg- und Hüttenwesen, vol. 39, p. 490.

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FIELD WORK.

By EDWARD W. PARKER and J. SHOBER BURROWS.

INTRODUCTION.

The collection of samples of coal for testing purposes for the year 1905 was begun by Mr. Burrows, under the direction of Mr. Parker, during the latter part of April. The early work consisted of shipping several samples of coal from Illinois, arrangements for which had been made during the Exposition period, but which could not be carried out until the work was resumed under the new appropriation.

Later, Messrs. John W. Groves and William J. Von Borries were employed as inspectors, and shipped most of the samples. Mr. Marius R. Campbell, of the United States Geological Survey, cooperated with the fuel-testing plant to the extent of shipping several samples of coal and lignite from points in the Western States, this work being done in connection with his geologic field work.

About May 1 an application form "to have coal tested at the United States Geological Survey coal-testing plant at St. Louis, Mo.," was sent to each operator of a shipping colliery in the United States. A descriptive circular accompanying this form set forth the conditions under which coal might be furnished for testing purposes, as follows:

1. The coal must be furnished to the testing plant free of cost to the Government.
2. The coal must be loaded under the supervision of one of the inspectors employed for that purpose, who shall be at the same time allowed to visit the working places in the mine to secure samples for analysis.
3. When it is possible to do so, the coal should be loaded in box cars and shipped under seal Lignites must always be shipped in this way.
4. Where the market requires screened coal, this grade will be accepted for tests. The selection of coal is always to be under the direct control of the representative of the testing plant
5. Where one of the problems involved is the better utilization of slack coal, a carload of slack may be accepted for testing purposes.
6. As soon as possible after the tests are completed, a brief statement of the results will be furnished to parties supplying the coal, for their information, but this must not be made public until the results are published by the Geological Survey.
7. Everyone interested in any particular test or in the general operation of the plant is invited to be present at any time, but the official record of the tests will not be given out except as indicated in the preceding paragraph.

The committee in charge of the work, recognizing the probability of receiving applications from two or more operators working the same seam of coal in the same locality, reserved the right to accept but one such application, in order that unprofitable duplication of results might be avoided.

The largest number of applications were received from Illinois, probably owing to the proximity of that field to St. Louis and the consequent low freight rates. Indiana, Ohio, West Virginia, and Tennessee follow Illinois in the number of applications, while Pennsylvania, Maryland, Virginia, Kentucky, and Alabama are well represented in the tests of coals from the Appalachian field, and Iowa, Missouri, Kansas, Arkansas, and Indian Territory in the tests of coals from the western interior fields. Applications for tests have also been received from North Dakota, Wyoming, Colorado, New Mexico, Utah, Washington, Oregon, North Carolina, and Georgia, and arrangements for meeting these requests have been made.

INSPECTION PROCEDURE.

In collecting the samples to be shipped to the plant, an inspector visits the mine and carefully examines the coal throughout its extent. He sees that the coal loaded for testing purposes fairly represents the average product of the mine; that when screened coal is to be sent, the size selected is available to the consumer and adapted to the purpose for which it is to be tested. Therefore, his first duty is to examine the screens and observe the method generally employed in separating the slate and other impurities from the coal while it is being loaded in the railroad car. He then enters the mine and notes carefully the character of the bed, the method of mining, and the amount of care taken by the miners to separate the shale partings and sulphur balls from the coal while loading it into mine cars. While the sample is being loaded into the railroad car the inspector stands inside and permits the slate pickers to discard only such material as is thrown off in the usual practice and as is consistent with the customary speed of loading. The material thrown out is afterwards examined by the inspector to determine why it is considered detrimental to the fuel value of the coal. When large amounts of slate, bone, iron pyrites, etc., have been discarded, the entire amount of refuse is weighed and noted in the inspector's report. Should the weight of this refuse exceed 2 per cent of the total weight of the sample of coal, the refuse is carefully sampled and analyzed. By this means an approximate idea of the reduction of ash and sulphur, due to hand picking, can be ascertained.

MINE SAMPLES.

Two or more samples for chemical analysis are taken by the inspector from working places in the mine. These analyses give the experts at the plant a definite idea of the quality of the coal before the practical tests are begun. They are also useful in showing the composition of the coal in its native condition; especially is this true of the moisture content. The object of the inspector is to secure a sample that will, as nearly as possible, represent run-of-mine coal.

The analytical results from mine samples taken during the Exposition period (August to December, 1904) showed that some modification of the method then used was desirable. These changes have been made with the idea of determining more accurately the amount of moisture in the coal in its native condition and of eliminating as far as possible the personal element, which figures so largely in all sampling where everything is left to the judgment of the sampler.

Mine sampling as it is done at present by the inspectors of the fuel-testing plant consists of first making a careful study of the coal throughout the mine and observing what parts of the bed are discarded by the miner. Two or more places where the coal is of average development are then selected. These places are usually at widely separated points in the part of the mine from which most of the coal is being shipped. The face is then cleared of burned powder, loose coal, and dirt for 5 feet or so, and insecure pieces of the roof are taken down to prevent their falling into the sample. The sampler then spreads a rubber blanket on the floor of the mine close up to the face of the coal and makes a perpendicular cut from floor to roof, including everything in the sample but the parts of the bed discarded by the miner. He cuts sufficient coal to make not less than 5 pounds per foot in height—that is, a sample weighing not less than 30 pounds would be cut from a 6-foot seam of coal. When shale or other partings are to be included in the sample, great care is exercised in cutting them the full width and depth of the groove in order to preserve the proper proportion of coal and extraneous matter. When the required amount of coal is obtained a detailed record is made of the section of the bed from top to bottom, every perceptible parting and variation in the section being noted. The parts of the bed not included in the sample are clearly shown in this record, and from these notes the value of the sample may be judged.

The cuttings are at once weighed and then sifted through a screen with a half-inch mesh. The remaining lumps are broken up in a portable grinding machine, and this process of screening and breaking is continued until the entire sample will pass through the screen.

The sample is then mixed by two men who stand opposite each other. Grasping the corners of the rectangular blanket, they roll the sample diagonally by raising one corner of the blanket at a time. This mixes the sample very thoroughly, and when the larger pieces are observed to be evenly distributed throughout the mass the sample is divided into four equal quarters. Two opposite quarters are discarded and the remainder mixed as before. If the sample is still too bulky to be conveniently handled, it is again mixed and quartered.

The remaining material is spread into a circular mass about 2 inches deep on the blanket, and a small trowel is used to fill a sample can with alternate sections of the sample taken from the circumference to the center of the mass around the entire circle. The can is closed and hermetically sealed with electrical insulating tape, and the weight is noted. This weight shows accurately what proportion of the original sample is sent to the laboratory,

The entire process of sampling is carried on as rapidly as possible at the place in the mine where the sample is cut. The maximum time for cutting and preparing a large sample is about one hour. Although it is known that rapid changes take place in the moisture content of some coals, it is reasonable to assume that where the sampling is quickly done in the atmosphere to which the native coal is exposed there is probably only a slight gain or loss of moisture while the sample is being broken up and quartered.

In an effort to establish some definite relation between these moisture changes and the atmospheric conditions, temperature, humidity, and dew-point determinations are made at the beginning and completion of the preparation of the sample. Similar readings are taken in the chemical laboratory. When sufficient data have been collected, it is possible that this subject will be more thoroughly understood.

DESIGNATION OF SAMPLES.

The samples or cars of coal when they are shipped are marked with the name of the State and numbered consecutively in the order of shipment. When two or three cars or lots constituting different grades of coal, such as lump, nut, etc., are shipped from the same mine, each lot is designated by a letter. For example, Illinois No. 1 A may be lump, Illinois No. 1 B nut, and Illinois No. 1 C slack, etc. These State numbers begin for 1905 where those in use during the previous work left off.

SAMPLES RECEIVED AND TESTED.

The following is a complete list of the car samples received during the period from May 1, 1905, to January 1, 1906, with details of ownership, location, character of sample, etc.:

Samples of coal

Name of sample.	Operator.	Mine.	Location.	Railroad.
California No. 1	San Francisco and San Joaquin Coal Co.	Tesla	Tesla, Alameda County, Cal.	Alameda and San Joaquin.
Illinois No. 6	Clover Leaf Coal Co.	Coffeen	Coffeen, Montgomery County, Ill.	Toledo, St. Louis and Western.
Illinois No. 7 A	Lumaghi Coal Co.	No. 2	Near Collinsville, Madison County, Ill.	Vandalia
Illinois No. 7 B	do	do	do	do
Illinois No. 7 C	do	do	do	do
Illinois No. 7 D	do	do	do	do
Illinois No. 8	Dering Coal Co	Paisley	Paisley, Montgomery County, Ill	Big Four
Illinois No. 9 A	Mount Olive and Staunton Coal Co.	No. 2	Near Staunton, Macoupin County, Ill.	Litchfield and Madison.
Illinois No. 9 B	do	do	do	do
Illinois No. 10	Dering Coal Co	West Frankfort	West Frankfort, Franklin County, Ill.	Chicago and Eastern Illinois.
Illinois No. 11 A	St. Louis and Big Muddy Coal Co.	Daws shaft	Near Carterville, Williamson County, Ill.	Illinois Central
Illinois No. 11 B	do	do	do	do
Illinois No. 11 C	do	do	do	do
Illinois No. 11 D	do	do	do	do
Illinois No. 12	Western Coal and Mining Co.	Bush No. 1	Bush, Williamson County, Ill.	St. Louis, Iron Mountain and Southern.
Illinois No. 13	The Benton Coal Co.	Benton	Benton, Franklin County, Ill.	Chicago and Eastern Illinois.
Illinois No. 14	Capital Coal Co	No. 2	East side of Springfield, Sangamon County, Ill.	Illinois Central
Illinois No. 15	Pettinger & Davis.	South	Centralia, Marion County. Ill.	do
Illinois No. 16	Big Muddy Coal and Iron Co.	No. 7	Herrin, Williamson County, Ill.	do
Illinois No. 18	La Salle County Carbon Coal Co.	La Salle shaft	La Salle, La Salle County, Ill.	do
Illinois No. 19 A	Zeigler Coal Co	Zeigler	Zeigler, Franklin County, Ill.	do

received and tested.

Inspector.	Kind of coal.	Name of bed.	Tests.
E. W. Parker.....	Lignite; run of mine.....	(?)	Producer-gas, p. 53.
J. W. Groves.....	Bituminous; run of mine...	No. 5.....	Steaming, p. 55. Producer-gas, p. 56. Washing, p. 57.
.....do.....	Bituminous; slack, through 1-inch mesh screen.	(?)	Producer-gas, p. 59.
J. S. Burrows.....	Bituminous; nut, over 1-inch mesh screen.	(?)	Producer-gas, p. 59.
.....do.....	Bituminous; slack.....	(?)	Steaming, p. 58. Producer-gas, p. 59. Washing, p. 60.
J. W. Groves.....	Bituminous; run of mine...	(?)	Steaming, p. 58. Washing, p. 60. Coking, p. 60.
Shipped by operator..	Bituminous; nut.....	(?)	Steaming, p. 61. Producer-gas, p. 62.
J. S. Burrows.....	Bituminous; run of mine...	(?)	Steaming, p. 63. Washing, p. 66.
.....do.....	Bituminous; lump.....	(?)	Steaming, p. 63. Producer-gas, p. 65.
Shipped by operator .	Bituminous; slack.....	(?)	Steaming, p. 67. Producer-gas, p. 68. Washing, p. 69.
J. S. Burrows.....	Bituminous; one-half screenings, one-half egg coal.	Big Muddy.....	Steaming, p. 70. Producer-gas, p. 72.
.....do.....	Bituminous; one-half run of mine, one-half lump coal.	.....do.....	Steaming, p. 70.
.....do.....	Bituminous; one-half No. 4 washed coal, one-half No. 5 washed coal.	.....do.....	Steaming, p. 70. Producer-gas, p. 72.
.....do.....	Bituminous; No. 3 washed coal.	.....do.....	Producer-gas, p. 72. Coking, p. 74.
J. W. Groves.....	Bituminous; run of mine...	No. 6.....	Steaming, p. 75. Washing, p. 76.
.....do.....	Bituminous; egg, through 6-inch screen and over 1½-inch screen.	No. 6.....	Steaming, p. 77. Producer-gas, p. 78. Washing, p. 79. Coking, p. 79.
.....do.....	Bituminous; lump, over 1½-inch bar screens.	No. 5.....	Steaming, p. 80. Producer-gas, p. 81. Washing, p. 82.
J. S. Burrows.....	Bituminous; lump, over 6-inch screens.	No. 6.....	Steaming, p. 83. Producer-gas, p. 84. Washing, p. 85.
.....do.....	Bituminous; mixture of lump and egg, made by passing run of mine coal over 3-inch mesh.	No. 7.....	Steaming, p. 86. Producer-gas, p. 86. Washing, p. 87. Coking, p. 88.
.....do.....	Bituminous; lump over 6-inch mesh screens.	No. 2.....	Steaming, p. 89. Producer-gas, p. 90. Washing, p. 91.
J. W. Groves	Bituminous; "¾-inch coal," over ¾-inch perforated shaking screens.	Big Muddy.....	Steaming, p. 92. Coking, p. 94.

Samples of coal

Name of sample.	Operator.	Mine.	Location.	Railroad.
Illinois No. 19 B....	Zeigler Coal Co...	Zeigler.....	Zeigler, Franklin County, Ill.	Illinois Central...
Indiana No. 3.....	J. Woolley Coal Co.	No. 3.....	Near Boonville, Warrick County, Ind.	Southern.....
Indiana No. 4.....	Consolidated Indiana Coal Co.	No. 29.....	Star City, Sullivan County, Ind.	Evansville and Terre Haute.
Indiana No. 5.....	.....do.....	No. 33.....	Hymera, Sullivan County, Ind.	.....do.....
Indiana No. 6.....	.....do.....	No. 34.....	.....do.....	.....do.....
Indiana No. 7 A....	S. W. Little Coal Co.	Little's.....	Little's, Pike County, Ind	.....do.....
Indiana No. 7 B....	.....do.....	.....do.....	.....do.....	.....do.....
Indiana No. 8.....	Deep Vein Coal Co.	Deep Vein.....	2 miles west of Terre Haute, Vigo County, Ind.	Vandalia.....
Indiana No. 9 A....	Fauvre Coal Co...	Red Bird.....	Macksville, Vigo County, Ind.	.....do.....
Indiana No. 9 B....	.....do.....	.....do.....	.....do.....	.....do.....
Indiana No. 10.....	Park County Coal Co.	.....	Near Rosedale, Park County, Ind.	.....do.....
Indiana No. 11.....	Island Coal Co...	No. 4.....	Dugger, Sullivan County, Ind.	.....do.....
Kansas No. 5.....	Southwestern Development Co.	No. 11.....	West Mineral, Kans.	Missouri, Kansas and Texas.
Kentucky No. 1 B..	Straight Creek Coal and Coke Co.	No. 2.....	Straight Creek, Bell County, Ky.	Louisville and Nashville.
Kentucky No. 1 C..	.....do.....	.....do.....	.....do.....	.....do.....
Kentucky No. 5....	Interstate Investment Co.	Gilliam's Rockhouse prospect.	Big Black Mountain, 15 miles from Louisville and Nashville Railroad.	Nearest Louisville and Nashville.
Kentucky No. 6....	Justus Collins....	Millers Creek country bank.	5 miles southeast of Paintsville, Johnson County, Ky.	7 miles from Chesapeake and Ohio.
Kentucky No. 7....	Central Coal and Iron Co.	Central.....	Central City, Muhlenburg County, Ky.	Illinois Central...
Maryland No. 1....	Piedmont and Georges Creek Coal Co	Washington No. 3	2 miles north of Westernport, Garrett County, Md.	Cumberland and Pennsylvania.
Massachusetts No. 1	.....	.....	Halifax, Plymouth County, Mass.	.....
North Dakota No. 1 B.	Consolidated Coal Co.	Lehigh.....	Lehigh, Stark County, N. Dak.	Northern Pacific..

received and tested—Continued.

Inspector.	Kind of coal.	Name of bed.	Tests.
J. W. Groves	Bituminous; "3-inch coal," over 1½-inch perforated shaking screens.	Big Muddy	Steaming, p. 92. Producer-gas, p. 93. Coking, p. 94.
do	Bituminous; nut and slack mixed.	No. 5	Steaming, p. 95. Producer-gas, p. 96. Washing, p. 96. Coking, p. 97.
J. S. Burrows	Bituminous; screenings, through 1¼-inch bar screens.	(?)	Steaming, p. 98. Washing, p. 99. Coking, p. 99.
do	Bituminous; run of mine	(?)	Steaming, p. 100. Producer-gas, p 101. Coking, p. 102.
do	do	(?)	Steaming, p. 103. Producer-gas, p. 104. Washing, p. 105. Coking, p. 105.
W. J. Von Borries	Bituminous; lump over 1¼-inch screen.	No. 5	Steaming, p. 106. Producer-gas, p. 107. Washing, p. 108. Coking, p. 108.
do	Bituminous; screenings through 1¼-inch screen.	do	Steaming, p. 106.
J. W. Groves	Bituminous; lump, over 1½-inch bar screen.	(?)	Steaming, p. 109. Producer-gas, p. 110. Washing, p. 111.
W. J. Von Borries	Bituminous; lump, over 1¼-inch screen.	No. 7	Steaming, p. 112. Producer-gas, p. 113. Coking, p. 114.
do	Bituminous; run of mine	do	Steaming, p. 112. Washing, p. 114. Coking, p. 114.
J. W. Groves	Bituminous; lump, over 1½-inch bar screen.	No. 6	Steaming, p. 115. Washing, p. 116.
do	Bituminous; lump, over 1½-inch and 3-inch screens.	No. 4	Steaming, p. 117. Producer-gas, p. 118. Coking, p. 119.
M. R. Campbell	Bituminous; over ¾-inch screens.	(?)	Producer-gas, p. 120.
J. W. Groves	Bituminous; one-half 3-inch and 1-inch coal, one-half ¾-inch coal.	Straight Creek	Producer-gas, p. 122. Coking, p. 123.
do	Bituminous; 1¼-inch slack coal.	do	Steaming, p. 121. Coking, p. 123.
J. S. Burrows	Bituminous; run of mine	High Splint	Steaming, p. 124. Producer-gas, p. 124. Coking, p. 125.
W. J. Von Borries	do	No. 1	Steaming, p. 126. Producer-gas, p. 127. Coking, p. 128.
J. W. Groves	Bituminous; standard lump, over 1½-inch bar screen.	No. 9	Steaming, p. 129. Producer-gas, p. 130. Coking, p. 131.
do	Bituminous; run of mine	(?)	Steaming, p. 132. Washing, p. 133. Coking, p. 133.
J. S. Burrows	Peat briquettes		Producer-gas, p. 134.
M. R. Campbell	Brown lignite	No name	Producer-gas, p. 136.

Samples of coal

Name of sample.	Operator.	Mine.	Location.	Railroad.
North Dakota No. 2 B.	Furnished by engineers of United States Reclamation Service.	Cedar Coulee.....	4 miles southeast of Williston, Williams County, N. Dak.	.....
North Dakota No. 3.	Washburn Lignite Coal Co.	Wilton.....	1 mile east of Wilton, McLean County, N. Dak.	Minneapolis, St. Paul and Sault Ste. Marie.
Ohio No. 1.....	Superior Coal Co..	No. 10.....	9 miles southeast of Wellston, Jackson County, Ohio.	Baltimore and Ohio.
Ohio No. 2.....	.....do.....	.....do.....	.....do.....	.....do.....
Ohio No. 3.....	Ohio Mining and Manufacturing Co.	Gosline & Barbour.	Shawnee, Perry County, Ohio.	Zanesville and Western.
Ohio No. 4.....	United States Coal Co.	Crow Hollow.....	Bradley, Jefferson County, Ohio.	Baltimore and Ohio.
Ohio No. 5.....	The Glens Run Coal Co.	Rush Run No. 1...	Rush Run, Jefferson County, Ohio.	Pennsylvania....
Ohio No. 6.....	Neff Coal Mining Co.	No 1.....	Neffs, Belmont County, Ohio.	Baltimore and Ohio.
Ohio No. 7.....	Forsythe Coal Co.	Forsythe.....	Danford, Guernsey County, Ohio.	.....do.....
Ohio No. 8.....	Upson Coal and Mining Co.	Dixie.....	Dixie, Perry County, Ohio.	.....do.....
Ohio No. 9 A.....	Gallia Mining Co..	Clarion	Clarion, Vinton County, Ohio.	Hocking Valley.
Ohio No. 9 B.....	.....do.....	.....do.....	.....do.....	.....do.....
Pennsylvania No. 4.	Jamison Coal and Coke Co.	Jamison No. 2....	4 miles north of Greensburg, Westmoreland County Pa.	Pennsylvania....
Pennsylvania No. 5.	James W. Ellsworth & Co.	No. 1 and No. 2...	Ellsworth, Washington County, Pa.	.....do.....
Pennsylvania No. 6.	Hustead-Seamens Coal and Coke Co.	Hustead-Seamens	East Millsboro, Westmoreland County, Pa.	.....do.....
Pennsylvania No. 7.	Old Colony Coal and Coke Co.	Ligonier.....	3 miles north of Ligonier, Westmoreland County, Pa.	Ligonier Valley...
Pennsylvania No. 8.	Pennsylvania Coal and Coke Co.	No. 3.....	Ehrenfeld, Cambria County, Pa.	Pennsylvania.....
Pennsylvania No. 9.	Reading Iron Co..	Kimmelton.....	Kimmelton, Somerset County, Pa.	Baltimore and Ohio.

received and tested—Continued.

Inspector.	Kind of coal.	Name of bed.	Tests.
.....	Brown lignite; run of mine..	No name.....	Producer-gas, p. 137.
M. R. Campbell.....	Brown lignite; lump.....	.....do.....	Steaming, p. 138. Producer-gas, p. 139.
J. W. Groves.....	Bituminous; run of mine from No. 4 bed.	No. 4.....	Steaming p. 140. Washing, p. 141. Coking, p. 142.
.....do.....	Bituminous; run of mine from No. 5 bed.	No. 5.....	Steaming, p. 143. Washing, p. 144. Coking, p. 144.
.....do.....	Bituminous; run of mine...	No. 6.....	Steaming, p. 145. Producer-gas, p. 146. Washing, p. 147. Coking, p. 147.
.....do.....	Bituminous; ¾-inch coal over ¾-inch bar screens.	No. 8.....	Steaming, p. 148. Producer-gas, p. 149. Washing, p. 150. Coking, p. 150.
.....do.....	Bituminous; "¾-inch coal," over ¾-inch bar screen.	Pittsburg, or No. 8.	Steaming, p. 151. Producer-gas, p. 152. Coking, p. 153.
W. J. Von Borries....	Bituminous; run of mine...	No. 8.....	Steaming, p. 154. Producer-gas, p. 155. Washing, p. 156. Coking, p. 156.
J. W. Groves	Bituminous; lump, over 1¼-inch bar screen.	No. 7.....	Steaming, p. 157. Producer-gas, p. 158. Washing, p. 159. Coking, p. 159.
.....do.....	Bituminous; run of mine...	No. 6 Hocking....	Steaming, p. 160. Producer-gas, p. 161. Washing, p. 162. Coking, p. 162.
.....do.....	Bituminous; lump, over 1¼-inch screen.	No. 4.....	Steaming, p. 163. Producer-gas, p. 165. Coking, p. 166.
.....do.....	Bituminous; nut and slack.	.....do.....	Steaming, p. 163. Washing, p. 165. Coking, p. 166.
.....do.....	Bituminous; lump, over 1¼-inch bar screen.	Pittsburg.....	Steaming, p. 167 Producer-gas, p 168.
W. J. Von Borries....	Bituminous; "¾-inch coal," over ¾-inch bar screen.	.....do.....	Steaming, p. 169. Producer-gas, p. 170. Washing, p. 171. Coking, p. 171.
J. W. Groves.....	Bituminous; run of mine...	.....do.....	Steaming, p. 172. Producer-gas, p. 173. Washing, p. 174. Coking, p. 175.
J. S. Burrows.....	.....do.....	Pittsburg, or Connellsville.	Steaming, p. 176. Producer-gas, p. 177. Washing, p. 178. Coking, p. 178.
.....do.....	.....do.....	Lower Kittanning.	Steaming, p. 179. Producer-gas, p. 180. Coking, p. 181.
W. J. Von Borries....	.....do.....	.....do.....	Washing, p. 182. Coking, p. 183.

Samples of coal

Name of sample.	Operator.	Mine.	Location.	Railroad.
Pennsylvania No.10	Pittsburg-Buffalo Coal Co.	Bertha.....	Bruce, Allegheny County, Pa.	Baltimore and Ohio.
Virginia No. 1.....	Interstate Investment Co.	H. C. Morris prospect.	Crab Orchard, Lee County, Va.	About 7 miles from Louisville and Nashville.
Virginia No. 2.....	Interstate Investment Co.	Big opening on Wilson farm.	Near Crab Orchard, Lee County, Va.	About 7 miles from Louisville and Nashville.
Virginia No. 3.....	Virginia Iron, Coal and Coke Co.	Coburn.....	Toms Creek, Wise County, Va.	Norfolk and Western.
Virginia No. 4.....	Darby Coal and Coke Co.	Darby.....	Darby, Lee County, Va.	Louisville and Nashville.
West Virginia No. 4.	Elkins Coal Co...	No. 2.....	Bretz, Preston County, W. Va.	Morgantown and Kingwood.
West Virginia No. 13.	Loup Creek Colliery Co.	Page No. 2.....	Page, Fayette County, W. Va.	Deepwater; Chesapeake and Ohio.
West Virginia No. 14.	.....do.....	Page No. 1.....	.....do.....	.....do.....
West Virginia No. 15.	Fairmont Coal Co.	Ocean.....	3 miles east of Clarksburg, Harrison County, W. Va.	Baltimore and Ohio.
West Virginia No. 16A.	.....do.....	Monongah No. 6..	Monongah, Marion County, W. Va.	.....do.....
West Virginia No. 16B.	.....do.....	.....do.....	.....do.....	.....do.....
West Virginia No. 17.	Elkins Coal Co...	Country bank....	2½ miles above Bretz, Preston County, W. Va.	Morgantown and Kingwood.
West Virginia No. 18.	Glen Alum Fuel Co.	Glen Alum.....	Glen Alum, Mingo County, W. Va.	Norfolk and Western.
West Virginia No. 19.	White Oak Coal Co.	McDonald.....	McDonald, Fayette County, W. Va.	Chesapeake and Ohio.
West Virginia No. 20.	Stevens Coal Co..	Keystone.....	Acme, Kanawha County, W. Va.	.....do.....
West Virginia No. 21.	Winifrede Coal Co.	Gas.....	Winifrede, Kanawha County, W. Va.	.....do.....
Wyoming No. 2B...	Cambria Fuel Co.	Antelope, Nos. 1 and 2, and Jumbo.	Cambria, Weston County, Wyo.	Burlington and Missouri River.
Wyoming No. 3....	Stilwell Coal Co..	.....	Sec. 27, T. 54 N., R. 61 W., at Aladdin, Crook County, Wyo.	Wyoming and Missouri River; Chicago and Northwestern.
Brazil, No. 1.....	.....	Sao Jeronymo....	Rio Grande do Sul, Brazil.	.....

received and tested—Continued.

Inspector.	Kind of coal.	Name of bed.	Tests.
W. J. Von Borries....	Bituminous; "¾-inch coal".	Pittsburg.....	Steaming, p. 184. Producer-gas, p. 185. Coking, p. 186.
J. S. Burrows.....	Bituminous; run of mine...	Wilson.....	Steaming, p. 187. Producer-gas, p. 188. Coking, p. 189.
.....do.....	.....do.....	McConnell.....	Steaming, p. 190. Producer-gas, p. 192. Washing, p. 192. Coking, p. 193.
W. J. Von Borries....	Bituminous; lump, over 3½-inch bar screen.	Upper Banner....	Steaming, p. 194. Producer-gas, p. 195. Coking, p. 196.
J. W. Groves.....	Bituminous; lump, over 1¼-inch bar screen.	Darby.....	Steaming, p. 197. Producer-gas, p. 198. Coking, p. 199.
.....do.....	Bituminous; run of mine...	Freeport.....	Washing, p. 200. Coking, p. 200.
E. W. Parker.....	.....do.....	Ansted.....	Steaming, p. 201. Producer-gas, p. 202. Coking, p. 203.
.....do.....	.....do.....	Eagle.....	Steaming, p. 204. Producer-gas, p. 205. Coking, p. 206.
J. S. Burrows.....	.....do.....	Pittsburg.....	Steaming p. 207. Coking, p. 208.
.....do.....	Bituminous; ¾-inch lump, over ¾-inch screen.	.....do.....	Producer-gas, p. 209. Coking, p. 210.
.....do.....	Bituminous; slack, through ¾-inch screen.	.....do.....	Washing, p. 209. Coking, p. 210.
J. W. Groves.....	Bituminous; run of mine...	Bakerstown.....	Steaming, p. 211. Washing, p. 212. Coking, p. 212.
.....do.....	.....do.....	Local Glen Alum .	Steaming, p. 213. Producer-gas, p. 214. Coking, p. 215.
.....do.....	.....do.....	Sewell.....	Steaming, p. 216. Coking, p. 217.
.....do.....	.....do.....	Keystone.....	Steaming, p. 218. Producer-gas, p. 220. Washing, p. 220. Coking, p. 221.
.....do.....	.....do.....	Winifrede.....	Steaming, p. 222. Washing, p. 224. Coking, p. 224.
M. R. Campbell.....	.....do.....	(?)	Steaming, p. 225. Producer-gas, p. 226.
.....do.....	Bituminous	(?)	Steaming, p. 227. Producer-gas, p. 228. Washing, p. 229. Coking, p. 229.
.....	Bituminous; run of mine...	.....	Steaming, p. 232. Producer-gas, p. 233.

SAMPLES COLLECTED AND EN ROUTE TO ST. LOUIS JANUARY 1, 1906.

The following samples were en route and in the yards of the fuel-testing plant January 1, 1906. The results of tests on these samples will appear in a later report:

Arkansas No. 1.—Slack coal for washing and coking tests furnished by Central Coal and Coke Company, of Kansas City, Mo., from mine No. 3, Huntington, Ark.

Arkansas No. 7.—Lump and slack coal for steaming, producer-gas, coking, and washing tests, furnished by Mammoth Vein Coal Company, of Midland, Ark., from Mammoth Vein mine, Midland, Ark.

Arkansas No. 8.—No. 4 coal for steaming and washing tests furnished by Consolidated Anthracite Coal Company, of Spadre, Ark., from No. 1 mine, Spadre, Ark.

Arkansas No. 9.—Slack coal for coking and washing tests furnished by Central Coal and Coke Company, of Kansas City, Mo., from mine No. 26, Bonanza, Ark.

Arkansas No. 10.—Lignite for producer-gas test furnished by Richmond Hibbard, of Camden, Ark., from mine L. O. U. No. 2, Lester Mill Company, Ark

Illinois No. 20.—Slack for steaming, coking, and washing tests furnished by the Mount Olive and Staunton Coal Company, of St. Louis, Mo., from mine No. 1, Staunton, Ill.

Indiana No. 12.—Run of mine coal for steaming, coking, and washing tests furnished by Patoka River Coal and Coke Company, of Huntington, Ind., from Hartwell mine, Hartwell, Ind.

Massachusetts No. 1.—Peat for producer-gas test furnished by C. L. Norton, Massachusetts Institute of Technology, Boston, Mass., from bog near Halifax, Mass.

Texas No. 3.—Lignite for producer-gas and briquetting tests furnished by J. J. Olsen & Son, of San Antonio, Tex., from Olsen mine, Olsen, Tex.

Texas No. 4.—Lignite for steaming, producer-gas, and briquetting tests furnished by Consumers Lignite Company, of Dallas, Tex., from mine No. 3, Hoyt, Tex.

WORK OF THE CHEMICAL LABORATORY.

By N. W. Lord.

INTRODUCTION.

The routine work of the laboratory and the general methods used in making the chemical and analytical tests on the samples of coal and other fuels tested at the fuel-testing plant, continue to be essentially the same as during the St. Louis Exposition and are described in the reports covering that period. [a]

NEW EQUIPMENT.

The temporary laboratory employed during the Exposition was very crowded and inconvenient owing to the limited space at the disposal of the fuel-testing plant for this work. Since that time the work has been done in a new laboratory fitted up in the foundry building left by the Exposition. This new laboratory is larger, more convenient, and better equipped in every way for the work, and materially facilitates accuracy and uniformity of results.

Under the head of "New equipment" may also be mentioned, for the analytical work, two additional analytical balances, an extra combustion furnace for ultimate work, an extra steel bomb for calorimeter work, and two calcium-chloride drying ovens of special design for the moisture determinations; for the sampling work, an especially designed drying oven, for facilitating the drying of the samples to a nearly air-dry condition, and a four-jar laboratory ball mill (manufactured by the Abbé Engineering Company), for final pulverization of the sample. These are mentioned more in detail under "Changes in methods."

During the Exposition city gas was used as a laboratory fuel. After the close of the Exposition this was not available and, as a consequence, gasoline gas is at present used in the laboratory. The machine used for supplying the gas is furnished by the Federal Gas Company, of St. Louis, Mo., and so far has proved satisfactory.

CHANGES IN METHODS.

In general the methods employed in the work have been only slightly changed from those in use during the Exposition. However, certain modifications have been introduced, following out lines developed in the experimental work of the laboratory. One of the most important of these is in regard to the preliminary or air drying of the samples. The earlier method of exposing the sample to the air of the laboratory proved unsatisfactory owing to the extremely varying moisture conditions resulting from the general character of the weather; the air drying loss in different samples of the same coal varied greatly, though it was, of course, accompanied by corresponding changes in the residual moisture of the coal and therefore did not materially affect the final statement of the analysis of the sample as received. In order to make determinations of the loosely held moisture more uniform and definite, a special drying oven has been designed and introduced into the laboratory; in this oven samples of several pounds weight can be dried in a gentle current of air raised from 10° to 20° above the temperature of the laboratory. In this way the coal is air dried in an

[a] Bull. U. S. Geol. Survey No. 261, 1905; Prof. Paper U. S. Geol. Survey No. 48, 1906.

atmosphere with a very low dew-point and not subject to large percentage variations, and the results obtained are considerably more concordant. Another advantage of this method is that it greatly shortens the time of air drying, so that the samples can be prepared in much less time than formerly. A detailed description of the apparatus will be presented in the complete report.

As it has been clearly demonstrated in the earlier work of the laboratory that there was a marked loss in moisture in many samples during the reduction of the air-dried sample and the weighing out for analysis, the system of sampling in this respect has been radically changed. The sample is ground in tight jars with quartz pebbles, in a ball mill. The ground sample is placed in wide-mouthed bottles and the sample for analysis mixed and weighed direct therefrom without pouring out and mixing, as was done in the earlier work. Direct comparison between samples reduced in this way and those ground on a bucking board or in an open mortar shows a distinct difference in the percentage of moisture, due to changes from the exposure during sampling.

PERSONNEL.

The personnel of the laboratory at present is as follows: Prof. E. E. Somermeier, in charge; Mr. F. M. Stanton, head chemist; Mr. G. A. Burrell first assistant ; Messrs. Karl M. Way and E. C. Waters, assistants.

WORK DONE IN THE LABORATORY.

From May up to January 1 the laboratory has received over 1,000 samples, representing coal from nineteen States and three Territories. The proximate analyses and sulphur determinations have been made on practically all of these, and the ultimate analyses, determinations of the heating value, and other special determinations have been made on such of the samples as have required the additional work.

In addition to the regular routine work on the coal samples, some tests on tars and some laboratory work on the washing of coal have been conducted, while a limited number of experimental lines of work have been followed up, in so far as the time at the disposal of the laboratory force has permitted.

Analytical results are presented in the detailed report on each sample (pp. 53–233).

WASHING TESTS.

By JOHN D. WICK.

INTRODUCTION.

As noted in the description of the washing tests made during 1904,[a] the lack of adequate storage facilities and the constant demand on the conveying and weighing apparatus for delivering coal to the boilers and producer greatly interfered with the washing tests and tended somewhat to vitiate the results.

IMPROVEMENT IN EQUIPMENT.

In order to eliminate these difficulties, important changes were made at the beginning of 1905 in the arrangement of the washery building. To the four 35-ton and two 17½-ton storage bins in use during 1904 were added five 35-ton bins, which increased the storage capacity of the washery building from 175 tons to 350 tons. The construction of three 50-ton auxiliary bins on the ground adjacent to the coke ovens further increased the capacity to 500 tons.

A 30-inch Jeffrey conveying belt was installed running from the car siding directly to the gas producer and boilers. This is used to deliver coal to the gas producer and boilers without crushing, or, in other words, in the same condition as when received from the mine. This conveyer has the additional advantage of relieving the main conveyer in the washery building of a large portion of work, leaving it available for use in connection with washing tests.

In rearranging the washing apparatus the Stewart modified jig in use during 1904 was retained, but the New Century jig was replaced by two Luhrig fine-coal jigs. The Stewart jig will wash coal composed of pieces crushed to 1½ inches in diameter, but the Luhrig jigs can be used only for coal one-half inch in diameter or less. With this equipment washing tests have been made with considerably better results than were obtained in 1904, and owing to the increased storage facilities larger samples of coal have been treated, affording a better opportunity for accurate adjustment of the jigs and for continuous runs approximating practical washing conditions. The water for washing tests is taken from the city mains and is reused by being pumped from the settling tank back to the jigs.

TESTS MADE.

Thirty-eight samples of coal from eight States, as enumerated below, were washed during the period from May 1, 1905, to January 1, 1906. The results of these washing tests will be found in the detailed report on each sample, presented on pages 53–233 of this report.

Illinois No. 6.—Run-of-mine coal from Coffeen mine, Clover Leaf Coal Company, Coffeen, Ill.; washed for steaming test.

Illinois No. 7.—Slack coal from No. 2 mine, Lumaghi Coal Company, Collinsville, Ill.; washed for steaming and coking tests.

Illinois No. 9.—Run-of-mine coal from No. 2 mine, Mount Olive and Staunton Coal Company, Staunton, Ill.

[a] Bull. U. S. Geol. Survey No. 261, 1905, p. 60.

Illinois No. 10.—Slack coal from West Frankfort mine, Dering Coal Company, West Frankfort, Ill. washed for steaming test.

Illinois No. 12.—Run-of-mine coal from Bush No. 1 mine, Western Coal and Mining Company, Bush, Ill.; washed for steaming test.

Illinois No. 13.—1¼-inch and 6-inch egg coal from Benton mine, Benton Coal Company, Benton, Ill.; washed for steaming test.

Illinois No. 14.—Lump coal from No. 2 mine, Capital Coal Company, Springfield, Ill.; washed for steaming test.

Illinois No. 15.—Lump coal from South mine, Pettinger & Davis Company, Centralia, Ill.; washed for steaming test.

Illinois No. 16.—Lump and egg coal from No. 7 mine, Big Muddy Coal and Iron Company, Herrin, Ill.; washed for steaming and coking tests.

Illinois No. 18.—Lump coal from La Salle mine, La Salle County Carbon Coal Company, Lasalle, Ill.; washed for steaming test.

Indiana No. 3.—Nut and slack coal from No. 3 mine, J. Wooley Coal Company, Boonville, Ind.; washed for steaming and coking tests.

Indiana No. 4.—Screenings from No. 29 mine, Consolidated Indiana Coal Company, Star City, Ind.; washed for steaming and coking tests.

Indiana No. 6.—Run-of-mine coal from No. 34 mine, Consolidated Indiana Coal Company, Hymera, Ind.; washed for steaming and coking tests.

Indiana No. 7.—Lump and nut coal from Little's mine, S. W. Little Coal Company, Littles, Ind.; washed for steaming and coking tests.

Indiana No. 8.—Lump coal from Deep Vein mine, Deep Vein Coal Company, Terre Haute, Ind.; washed for steaming test.

Indiana No. 9.—Run-of-mine coal from Red Bird mine, Fauvre Coal Company, Macksville, Ind.; washed for steaming test.

Indiana No. 10.—Lump coal from No. 10 mine, Park County Coal Company, Rosedale, Ind.; washed for steaming tests.

Maryland No. 1.—Run-of-mine coal from Washington No. 3 mine, Piedmont and Georges Creek Coal Company, near Piedmont, W. Va.; washed for steaming and coking tests.

Ohio Nos. 1 and 2.—Run-of-mine coal from No. 10 mine, Superior Coal Company, near Wellston, Ohio; washed for steaming and coking tests.

Ohio No. 3.—Run-of-mine coal from Gosline & Barbour mine, Ohio Mining and Manufacturing Company, Shawnee, Ohio; washed for steaming and coking tests.

Ohio No. 4.—Three-fourths inch coal from Crow Hollow mine, United States Coal Company, Bradley, Ohio; washed for steaming and coking tests.

Ohio No. 6.—Run-of-mine coal from No. 1 mine, Neffs Coal Mining Company, Neffs, Ohio; washed for steaming and coking tests.

Ohio No. 7.—Lump coal from Forsythe mine, Forsythe Coal Company, Danford, Ohio; washed for steaming and coking tests.

Ohio No. 8.—Run-of-mine coal from Dixie mine, Upson Coal and Mining Company, Dixie, Ohio; washed for coking tests.

Ohio No. 9.—Screenings from Clarion mine, Gallia Mining Company, Clarion, Ohio; washed for steaming and coking tests.

Pennsylvania No. 5.—Three-fourths inch coal from No. 2 mine, James W. Ellsworth & Co., Ellsworth, Pa.; washed for steaming and coking tests.

Pennsylvania No. 6.—Run-of-mine coal from Hustead-Seamens mine, Hustead-Seamens Coal and Coke Company, East Millsboro, Pa.; washed for steaming and coking tests.

Pennsylvania No. 7.—Run-of-mine coal from Ligonier mine, Old Colony Coal and Coke Company near Ligonier, Pa.; washed for steaming and coking tests.

Pennsylvania No. 9.—Run-of-mine coal from Kimmelton mine, Reading Iron Company, Kimmelton, Pa.; washed for coking test.

Virginia No. 2.—Run-of-mine coal from McConnell mine, Interstate Investment Company, near Crab Orchard, Va.; washed for steaming and coking tests.

West Virginia No. 4.—Run-of-mine coal from No. 2 mine, Elkins Coal Company, Bretz, W. Va.: washed for coking test.

West Virginia No. 16.—Slack coal from Monongah No. 6 mine, Fairmont Coal Company, Monongah, W. Va.; washed for coking test.

West Virginia No. 17.—Run-of-mine coal from country bank, Elkins Coal Company, near Bretz, W. Va.; washed for steaming and coking tests.

West Virginia No. 20.—Run-of-mine coal from Keystone mine, Stevens Coal Company, Acme, W. Va.; washed for steaming and coking tests.

West Virginia No. 21.—Run-of-mine coal from Gas mine, Winifrede Coal Company, Winifrede, W. Va., washed for steaming and coking tests.

Wyoming No. 3.—Run-of-mine coal from mine of Stilwell Coal Company, Aladdin, Wyo.; washed for steaming and coking tests.

STEAMING TESTS.

By L. P. Breckenridge.

EQUIPMENT.

The steaming tests under the Heine boilers have been continued under practically the same conditions as the 78 trials made during the period of the Louisiana Purchase Exposition. For convenience the principal proportions of the boiler settings are shown in the following table:

Leading proportions of the two Heine water-tube boilers used in the fuel-testing plant.

	Boiler No. 1.	Boiler No. 2.
Rated capacity of boiler.....horse power..	210	210
Water-heating surface.....square feet..	2,031	2,031
Superheating surface.....	None.	None.
Grate area.....square feet..	40.55	36.4
Air space through grate.....per cent..	45	35
Available stack draft.....inches of water..	.75	.75
Height of steel stacks.....feet..	115	115
Area of steel stacks.....square feet..	7.67	7.67
Number of 3¼-inch tubes on each boiler.....	116	116
Usual steam pressure carried.....pounds..	80	80

The two boilers used for these tests are exactly similar in construction and setting. Each is provided with its own stack and fed by its own injector. The scales and instruments used in the trials are frequently checked and maintained in an accurate condition.

IMPROVEMENTS AND ADDITIONS.

After the completion of the World's Fair series of steaming tests a few changes in the settings were made, as follows:

A McClave rocking grate was installed under boiler No. 2. It was thought that some coals could be handled more satisfactorily on a grate of this type and this proved to be the case. The B. F. Sturtevant Company loaned the plant a forced-draft outfit, consisting of blower and direct-connected steam engine. This has been set up so as to discharge air into the closed ash pits under each grate. By the aid of a light draft it has been possible to burn lignites high in moisture with fair results. A series of trials with slack coals and dried lignites is contemplated later.

The brick walls have been given two coats of paint and all cracks and openings have been carefully stopped with asbestos paste. A special air-leakage test box has been used to locate leaks of air in the settings and all leaks have been promptly stopped.

During the first weeks of this series of trials several gas-mixing devices were tried in the combustion chamber, such as fire-brick honeycombs, but they lacked durability, perhaps because of faulty construction and inferior material. A honeycomb wall was then built of very large fire-clay shapes, 6 by 12 by 18 inches, which withstood the heat for six months.

Considering the facts that the floor of the combustion chamber had no special rigidity and that this was our first experience in selecting material for and erecting such a structure, it is fair to assume that it is commercially practicable to use such mixing structures in combustion chambers.

The object of this construction is to subdivide and mix the gases coming from the fuel bed and to cause them to travel a greater distance before striking the cold tubes. These fire-clay masses also absorb heat between firings and give it out just after firings when there is a large rush of cold air and hydrocarbons.

Recently the lowest row of tubes of boiler No. 2 has had the protecting tiles changed from the "C" to the rectangular flat-bottomed type. The "C" tiles gave much trouble from breakage due to radiant heat and were also frequently broken with fire tools. The flat-bottomed tiles are more durable and will be put on the other boiler as soon as its "C" tiles need replacing. The rectangular tiles weigh about the same as the "C" tiles.

On measurement of the areas left between the tubes at the end of the lower and upper baffles where the gases respectively enter and leave the boiler tubes, it was found that a much shorter length of openings would do, so more tube tiles were added below and more iron tiles above until the openings were each reduced nearly one-half; thus forcing the gases to travel a slightly greater length of tube surface.

The following new instruments have been added since the tests of last year: One Crosby recording steam gage, one Bristol recording draft gage, one Bristol recording flue thermometer, one Wanner optical pyrometer.

The instruments have served as a check on the regular observations. They have been checked with the other instruments used for the same readings. The optical pyrometer used for reading combustion-chamber temperatures has been easily handled and has been found exceedingly useful in this work.

These modifications of the equipment have perhaps improved the over-all efficiencies of this year's (1905) tests 2 or 3 per cent over last year's.

PERSONNEL.

Prof. Dwight T. Randall, who had local charge of the steaming tests in 1904, returned to the University of Illinois, and Mr. Walter T. Ray, of the Chicago Edison Company, was appointed to the vacancy. Later Mr. Clyde McClure resigned as boiler-room chemist, to assume duties with the above company, and was replaced by Mr. Ralph Galt, of the University of Michigan. The same fireman, Mr. Henry Arens, has been employed continuously since the tests began. Mr. Robert H. Kuss, until recently instructor on steam boilers at the University of Illinois, has joined our local staff, as have Messrs. Lloyd R. Stowe, W. M. Park, Fred E. Pahmeyer, and R. C. Matthews. The following men have also been with the work from the start: Messrs. Henry Kreisinger, H. W. Weeks, R. H. Post, and C. H. Green.

CHANGES IN METHODS OF TESTING.

The only important change introduced in test procedure consisted in making three trials with each coal, but the three ran so nearly alike that hereafter only two will be made. In the first series only one trial was made with each coal. The feeling has been that some changes in proportions of baffling might increase the over-all efficiency of all the trials. Still the temptation to make any marked changes has been resisted, in the belief that the object for which these tests are being conducted will be better served by keeping to the same ratios in all the tests. The results will then more truly show the comparative value of the various fuels than they would if changes in the setting were attempted.

WORK DONE.

On 64 coals, some of them washed in part, there were made 185 tests, which are included in this report; several tests were thrown out. Coals were tested from Illinois, Indiana, Kentucky, Maryland, North Dakota, Ohio, Pennsylvania, Virginia, West Virginia, and Wyoming.

FEATURES OF THE INVESTIGATION.

It is probable that the general efficiencies obtained are fairly good. But the Survey clearly realizes that it is working with limits imposed by its particular apparatus, though these limits are not the fault of the Heine construction, inasmuch as any combination of grate, furnace, and boiler would have faults. For this reason and others all steaming tests are only approximately comparative and not final as between coals. Steaming tests should be made more with the idea of eliminating them in future years than of accepting them as final. Toward this end engineers should work with the aid of chemistry and physics.

The determination of the calorific capacity of the various steaming coals has shown, during the last few years, that these coals contain a larger number of heat units than were formerly credited to them. This has resulted in somewhat lower efficiencies than have sometimes been reported.

Before closing the present series of trials it is hoped that tests may be made with several standard coals, which will show the effect of changes in certain fundamental ratios on the over-all efficiency of these outfits.

Some of the more important results of the steaming tests are given on pages 53–233, in the detailed report on the various coal samples used.

SPECIAL TESTS.

Attention is called to some special tests made during the period covered by this report, as follows:

TESTS ON MIXED COALS.

Tests Nos. 240, 248, and 254 were made on Virginia No. 4. In the first test the clinker fused onto the grate so as to be very difficult to remove; in the two remaining tests about 200 pounds of nut-sized limestone was spread over the grate before starting, so that the clinker lifted up very easily. The average boiler efficiency for these three tests was 66.6 per cent.

Test No. 242 was run on Pennsylvania No. 8 dried. The boiler efficiency was 68.3 per cent. Cleaning was very easy. The Virginia coal was very free burning and long flaming, and the Pennsylvania coal very short flaming. It was thought that by mixing them, as a matter of experiment, a better result would be attained; but the boiler efficiency was only 61.7 per cent. There were outside reasons for the result being low, but the best that can be said is that the experiment was indeterminate. The grate behavior was improved.

TESTS ON DRIED COALS.

Some of Pennsylvania No. 8 was dried and burned in test No. 242. The moisture to start with was only about 3 per cent and it was reduced to 0.42 per cent by drying in a Bartlett rotary drier at 240° F. At the same time some of the volatile matter was driven off, so that the British thermal units of the dry coal fell from about 14,800 to 14,660; with the average boiler efficiency of the four tests run on the coal as received, the performance was a shade better only, and on the whole there was a considerable loss.

Two tests, Nos. 243 and 244, were run on Ohio No. 9 B, dried after washing, with a slight loss of efficiency, not to speak of the drying having reduced the British thermal units of the dry coal about 1.5 per cent, as in the other case.

These drying tests were made as preliminary to some tests to be run on dried lignites.

TWENTY-FOUR HOUR RUNS.

It can be calculated that from 1 to 2 per cent of the heat generated in a test is lost in heating the brickwork in the morning, notwithstanding that the furnace is fired hard for two hours before starting. To learn something of this, some tests were run on the same coals, starting the very instant the preceding ones ended. The preceding test numbers were 237, 243, and 249; average boiler efficiency, 66.2 per cent; average furnace temperature, 2,388° F. The immediately succeeding test numbers were 238, 244, and 250; average boiler efficiency, 67.3 per cent; average furnace temperature, 2,355° F. These tests show an average gain of 1.1 per cent, which is nonconclusive. The research is being continued.

PRODUCER-GAS TESTS.

By ROBERT H. FERNALD.

EQUIPMENT.

In order that the work outlined for 1905 by the gas-producer division of the fuel-testing plant might be completed in the time allowed, it became necessary to increase the capacity of the plant. Accordingly, a second producer with its economizer was installed, so that the plant now consists of two independent producers, both discharging into the same scrubber. These producers are worked independently, one being charged while the other is in operation. By this arrangement no time is lost in changing from one coal to another at the end of any test, as a simple manipulation of valves brings the second producer into operation when the first is cut out. The remainder of the operating portion of the plant has not been changed, so far as new installations are concerned, though several changes in detail have been made from time to time as the nature of the work demanded. Some of these changes are noted later in this report.

Owing to the fact that the chemical laboratory originally installed in connection with this division of the plant was far from adequate, a special building was erected sufficiently near the gas holder and engine to reduce inaccuracies in gas sampling and other similar work to a minimum and at the same time providing comfortable accommodations for the chemists.

PERSONNEL.

Capt. John A. Laird, a consulting engineer of St. Louis, who has been connected with the plant since September, 1904, has continued the supervision of the operating details of the tests and since December 1, 1905, has also had active charge of the mechanical operation of the producers. Until December 1 the manipulation of the producers was directed by Mr. C. O. Nordensson, of R. D. Wood & Co., who remained with the testing plant about a year. Since the renewal of operations in May, 1905, Mr. J. P. Quam, of the Westinghouse Company, has had supervision of the operations of the gas engine. He has had as assistant engineers Messrs. R. E. Peshak and F. V. Roy. The computations have been in charge of Mr. W. C. Weidmann, assisted by Mr. Kurt Toensfeldt. Until about July 1, 1905, the chemical work of the producer-gas tests was directed by Mr. H. G. Ecker, with Messrs. H. A. Grine and J. G. Goodwin as assistants. Since that date Mr. Grine has been head chemist, with Messrs. J. G. Goodwin and W. L. Hempelmann as assistants. The observations have been made by Messrs. Curt Adler, C. L. Armstrong, L. A. Delano, S. P. Howell, W. B. Lemmon, and Julien Teza.

IMPROVED CONDITIONS OF TESTING.

The operating conditions from May 1 to December 31, 1905, have been far superior to those that were possible during the Exposition period of 1904, and the results presented in this report have been subjected to refinements that were not attainable in the previous operation of the plant. A comparison of these figures with those obtained during 1904, published in Bulletin No. 261 (1905) and Professional Paper No. 48 (1906) of the United States Geological Survey, will show the general increase in efficiency of manipulation due to the improved conditions.

The determination of the amount of coal actually burned in the producer for any given period is, at best, a factor of more or less uncertainty. To reduce the possible error to a

minimum, it was deemed necessary to make the test on each coal as long as consistent. A schedule was therefore adopted at the beginning of this series of tests involving two sixty-hour runs per week. The first eight to twelve hours of each test period are used for getting the fuel bed into uniform and efficient condition. During these preliminary hours records are taken as in the regular tests, but the official test, as reported, includes only the last forty-eight or fifty hours of the run, during which time the conditions are maintained as uniform as possible. Special attention is being directed to the very important item of measurement of the coal actually used and special charts and checking devices have been introduced for this purpose.

Owing to the lack of reliability in the operation of the gas engine, many of the tests conducted during the Exposition period were of a few hours' duration only, but since the present series of tests began (May, 1905) no difficulty has been experienced in starting the engine at 8 a. m. Monday and continuing day and night without a stop until 8 a. m. Saturday. During this period two different coals are tested, and the change of gases is made at 8 p. m. Wednesday without stopping the engine.

NUMBER OF TESTS MADE.

During the period from May 1, 1905, to January 1, 1906, sixty-four producer-gas tests have been made. One of these tests was run on coke breeze and one on Brazil coal. The remaining sixty-two were divided as follows among different States: California, three tests on lignite and locomotive cinders; Illinois, eighteen tests on coal; Indiana, eight tests on coal; Kansas, one test on coal; Kentucky, four tests on coal; North Dakota, three tests on lignite; Ohio, seven tests on coal; Pennsylvania, seven tests on coal; Virginia, four tests on coal; West Virginia, five tests on coal; Wyoming, two tests on coal.

SPECIAL FEATURES OF THE INVESTIGATIONS.

The results of the majority of the tests have been exceedingly gratifying, official records having been made as low as 0.95 pound of dry coal per hour burned in the producer per electrical horsepower developed at the switchboard, or 0.80 pound of dry coal per hour burned in the producer per brake horsepower, on the basis of an assumed efficiency of 85 per cent for generator and belt.

Throughout the tests a constant effort has been made to do away with unnecessary appliances. This effort has furnished valuable and interesting information and has centered attention on several radical changes in the details of producer-gas plant construction.

It was found at an early date that more or less sulphur was passing the purifier and entering the engine cylinders. Investigations by the chemists showed that purifiers consisting of oxidized iron filings and shavings are fairly efficient for coals containing little sulphur—1 per cent or less; but it was found that for coals containing larger percentages of sulphur the purifier became completely exhausted after about six or eight hours. Mixtures of lime and shavings were tried, but with little success. As a result of these investigations the purifier has been discarded, and the gas, carrying its full percentage of sulphur, has been charged directly into the engine cylinders. This method of operating has been going on for many months, and no ill effects have been discovered, though coal has been used containing as high as 8.1 per cent of sulphur.

One feature of the plant as installed was the economizer, used for preheating the air for the blast. A series of experiments has shown no effect on the chemical composition of the gas or on the efficiency of the plant when air at ordinary atmospheric temperature was substituted for preheated air. As a result the economizer, as an economizer, has been discarded and the construction of the plant again simplified.

Other modifications and changes are under investigation at the present time, the most important from an economic standpoint relating to the utilization of slack coal in producers.

The results of the producer-gas tests will be found in the detailed report on each sample presented on pages 53–233.

COKING TESTS.

By A. W. BELDEN.

EQUIPMENT.

The ovens in which the tests of the coking qualities of coals have been made are of the regular beehive pattern. Of the battery of three ovens, two are of standard size, 12 feet in diameter and 7 feet high; the third is 12 feet in diameter and 6 feet 4 inches high. This change was made by raising the bottom of one of the standard ovens 8 inches with well-tamped loam and bottom tile of the usual size. The object of this was to bring the charge nearer the dome of the oven and effect a more rapid penetration of heat.

For the first 19 tests only the small oven was used. In the twentieth charge one of the 7-foot ovens was blown in, and both have been used continuously during the remainder of the work. Owing to the limited supply of coal it has not been possible to use more than two ovens. Both of these ovens may therefore be considered as end ovens, which by some are supposed to yield results less favorable than those from ovens located between other heated ovens; though, were this supposition correct, the difference would be fully balanced by the greater care bestowed on these experimental ovens as compared with ovens operated under normal conditions. Since both of the ovens used are, in the sense indicated, end ovens, the results obtained in each are comparable one with the other.

In charging the ovens for the first nineteen tests the larry used held less than 1 ton. This necessitated the filling and emptying of the larry six to eight times before the charge was completed. Each portion thus became hot and began to gas, invariably, and often to blaze, before the next portion of the charge was added. This unfortunate state of affairs is believed to be responsible, at least in some measure, for cross lamination and cross breakage of the coke, in many of these tests layers of coal as charged showing plainly in each oven drawn. The average time of charging with this device was about one hour; the whole charge should be put in at once and as rapidly as possible.

After the nineteenth charge a standard-size larry, kindly loaned by the H. C. Frick Coke Company, was installed and this lamination and cross breakage disappeared, while the time of charging was reduced to an average of seven minutes.

PERSONNEL.

The writer took charge of this work in May, succeeding Mr. Fred. W. Stammler, of Johnstown, Pa. He was assisted by Mr. W. E. Vickers, of Pocahontas, Va., to whom in large measure is due whatever success has been accomplished during these investigations.

PROCEDURE OF TESTS.

All coal was finely crushed through a Williams mill unless otherwise requested and these exceptions are noted in the subjoined detailed report (pp. 53–233). The coals marked "not crushed" were, when unloaded from the cars, put through rolls having an aperture of 1¼ inches. The coals put through the Williams mill will practically all pass through a 10-mesh sieve.

The ovens were always closed, both door and trunnel head, directly after being drawn, and allowed to gather heat, the length of time varying as necessity demanded. The average time was one hour and a half.

The sample of coal was taken at regular intervals as the charge was emptied from bin to larry, using a small shovel holding about a quarter of a pound; the total weight of the sample averaged 45 pounds.

The sample of coke was taken from five different parts of the oven, as nearly as possible from the same location for each test: One piece 2 feet from the oven door; one 2 feet from each side, on a line drawn from the center of the oven; one from the center, and one 2 feet from the back wall, on a line with the point of selection of the pieces taken from the door and the center. The separate pieces of coke extended the whole height of the charge, and were as nearly uniform in size as possible.

In beginning the series of tests the first charges showed a rather large percentage of breeze, this being before the ovens were fully seasoned, and black butts due to cold bottom were produced. It was unfortunate that these first tests should have been on supposedly noncoking coals, as the condition of the oven did not permit it to give as effective service as would probably have been the case under other and more favorable circumstances.

EXTENT OF TESTS.

In the scope of this report, covering the period from July 7 to December 20, are included results from 94 tests of 46 coals from 9 different States, as follows: Illinois, 5; Indiana, 7; Kentucky, 4; Maryland, 1; Ohio, 9; Pennsylvania, 6; Virginia, 4; West Virginia, 9; Wyoming, 1. Of these tests, 60 were of raw coal, 32 of washed coal, 1 of raw coal with the addition of pitch, and 1 of washed coal with the addition of pitch.

Of the 46 different coals, six produced no coke, viz, Illinois No. 16 and No. 19, Indiana No. 3, Ohio No. 3, Maryland No. 1, and Wyoming No. 3. No coke was obtained from Illinois No. 16 owing to an accident to the larry; the test was discontinued. Maryland No. 1 was coked by the addition of 10 per cent pitch to washed coal. Wyoming No. 3 is a lignite. Four tests were made on Pennsylvania No. 9; two gave only a few pieces of coke, a third produced coke of inferior quality, and the fourth, with the addition of 5 per cent pitch to raw coal, produced coke, but of no better quality than that from washed coal.

The results of the coking tests will be found in the detailed report on each sample, presented on pages 53–233.

FURTHER TESTS.

It is intended to experiment further with the addition of volatile hydrocarbons to noncoking coals and coals producing an inferior grade of coke. Conclusions from these experiments will be incorporated in a later and more complete report.

BRIQUETTING TESTS.

By J. A. Holmes.

CHANGES IN EQUIPMENT.

The briquette machine used in the larger part of the testing work during 1905 was the one built by Wm. Johnson & Sons, of Leeds, England, referred to in the reports of this work for 1904.[a] The American machine referred to in the same report was returned to the owners at the end of 1904. Briquettes made on the English machine during 1904 measured 4¼ by 6¾ by 5½ inches and averaged in weight 6.8 pounds. To obtain a briquette that would more nearly fulfill the requirements of domestic use and of stationary and locomotive boiler practice, it was thought advisable to reduce the size. To this end the mold wheel on the machine was planed down so as to make a briquette 2½ inches (instead of 5½ inches) in thickness, the other dimensions remaining the same. By adjusting the machine to meet this change it was possible to make satisfactory briquettes weighing about 3¼ pounds, and these were used in the tests mentioned below.

With a view to obtaining a greater range in the size of the crushed fuel for the briquettes, a series of pulleys was installed on the driving and driven shafts operating the disintegrator, giving approximately 80, 65, and 50 per cent of its original speed. The necessary improvements were also made in the construction of this machine, such as a wider driving belt, extension of the elevator feeding the pug mill, proper drainage for the exhaust pipe, jacketing steam pipes, etc. By these improvements easier and more continuous operation was secured.

To determine with a fair degree of accuracy the percentage of binder being used with each fuel in the English briquetting machine, a gate was placed at the point where the small screw conveyor discharges the pitch into the mixing screw conveyor containing the coal. The percentage of binder was determined by weighing coal and binder, and, by experiment, the proper opening of the gate for each percentage of binder was determined.

PERSONNEL.

Mr. C. T. Malcolmson, the mechanical engineer in charge of the general work about the fuel-testing plant, has made the alterations in the briquetting equipment mentioned above and has also conducted the tests made on the English briquette machine. Prof. A. A. Steel, of the University of Arkansas, who superintended this work during 1904, has aided in the tests of 1905 in an advisory capacity. Dr. J. E. Mills, of the University of North Carolina, who served as chemist of this division from May 1 to October 6, 1905, conducted a series of laboratory experiments on the relative merits of different binding materials referred to in the following section.

[a] Bull. U. S. Geol. Survey No. 261, 1905, p. 13; Prof. Paper U. S. Geol. Survey No. 48, 1906, p. 25.

LABORATORY INVESTIGATIONS.

In the laboratory investigations by Dr. J. E. Mills the substances named below were tested as binding materials in the manufacture of briquettes, both as to the possibility of their being used with the different varieties of bituminous coal and as to the percentage of each binder yielding the best results with each coal. The substances tested in this connection were as follows:

INORGANIC BINDERS.

Clay.	Plaster of Paris.
Lime.	Portland cement.
Magnesia.	Natural cement.
Magnesia cement (magnesium oxide and magnesium chloride).	Slag cement.
	Water glass.

ORGANIC BINDERS.

A. Wood products.

Rosin.	Douglas-fir tar.
Pitch (rosin and tar).	Wood pulp.
Pine-wood tar.	Sulphite liquor (from paper mills.)
Hard-wood tar.	

B. Sugar-factory residues.

Beet pulp.	Beet-sugar molasses.
Lime cake.	Cane-sugar molasses.

C. Starch.

Corn starch.	Potato starch.

D. Slaughterhouse refuse.

E. Tars and pitches from coal.

Blast-furnace tar.	By-product coke-oven tar.
Producer-gas tar.	Coal-tar creosote.
Illuminating-gas tar (from coal).	Various grades of pitches from various tars.

F. Natural asphalts.

Impsonite.	Refined Bermuda.
Gilsonite.	Hard and refined or gum (from impregnated sandstone, etc.).
Maltha.	
Refined Trinidad.	

G. Petroleum products.

Crude oil.	Acid sludge.
Residuum (asphalts, etc.).	Asphalt tar.
Water-gas tar.	Pintsch-gas tar.
Water-gas tar pitch.	Pittsburg flux.
Wax tailings.	

These investigations related not only to the nature and the amount of the binder necessary for making satisfactory briquettes with each of the several coals tested, but also to the extent to which the binding quality of certain of these materials might be improved by the admixture of another binding material or another variety of coal.

Unless otherwise stated, 20 grams of each coal to be tested were weighed out and mixed with the different percentages of the binding material and placed in a Battersea crucible. A small amount of water was then added and the mixture heated with sufficient stirring to thoroughly mix the binder and coal until steam came off freely and only a small amount of water was left in the coal. The mixture while still hot was pressed in a small laboratory hand press, on which a pressure of 3,500 to 4,000 pounds per square inch was obtained. Each briquette weighed approximately 5 grams.

TESTS OF BINDING MATERIALS.

There is need for much additional investigation on a larger scale before definite results can be stated concerning the several possible binding materials for briquette manufacture; but the examinations made by Doctor Mills developed certain results which are at least suggestive.

The use of inorganic binding materials such as those mentioned above is not likely to prove practicable under any ordinary conditions, except that in the case of noncoking coals, when coking coals can not be obtained to mix with them, a small percentage of certain of these materials (such as magnesium oxide or carbonate, plaster of Paris, etc.), if added to other binding materials, may cause the briquettes to hold together better in the fire and hence undergo more complete combustion. It was not expected that all of these substances could be successfully used as binding materials in the manufacture of briquettes; nevertheless it was believed that an examination of each substance as to its adaptability for this purpose might throw some light on the general problem under consideration.

Of the more specific results in the testing of different binding materials, the following tentative statements are made, pending further investigations:

The use of clay, lime, and cements as binding materials was found entirely unsatisfactory, for the reason that they add largely to the ash constituent of the briquette. The briquettes made with these materials as bond went to pieces on exposure to water and weather and their waterproofing by soaking in oils, etc., was found difficult and expensive. Water glass (or soda silicate) was also found to be unsuitable for use in this connection.

From 4 to 6 per cent of magnesium oxide used as a binder was found to hold the briquettes together satisfactorily in dry weather and in the fire, but they disintegrated on exposure to rainy weather or when immersed in water.

In the tests with plaster of Paris, from 2 to 12 per cent of this material being used as a binder, the briquettes made were hard but brittle, and quickly disintegrated on exposure to moisture. Three per cent of magnesia mixed with 6 to 8 per cent of water-gas tar pitch seemed to make a stronger briquette than the same percentage of pitch used alone; but the improvement in the quality of the briquette is not considered sufficient to cover the additional cost of the magnesia and the additional percentage of ash which it brings into the briquette. Furthermore, this addition of sulphur to the coal is undesirable.

None of the sugar-factory residues, namely, beet pulp, lime cake, beet-sugar molasses, and cane-sugar molasses, were considered satisfactory as binding materials, for the reason that the briquettes made with them disintegrate on exposure to the weather, and no inexpensive waterproofing has as yet proved satisfactory on a commercial scale.

Nor were any of the wood products, including rosin, pitch, pine-wood tar, hard-wood tar, Douglas-fir tar, wood pulp, and sulphite liquor from paper mills, when used alone regarded as satisfactory, though some of these materials used in combination with other binders gave results of some promise, and deserve further investigation.

The tests made using from 0.5 to 3 per cent of starch as a binding material with different coals gave briquettes which were strong, were smokeless in burning, and held together in the fire until completely consumed; but these briquettes went to pieces when wet or exposed to the weather for a considerable period of time. Experiments as to the possibility of cheaply waterproofing the briquettes bound with starch, so as to make them hold together when exposed to water, were sufficiently successful to warrant further investigation in this direction. Starch is obtainable in large quantities and can be easily produced in almost any part of the country. In its crude form it can probably be obtained at a price less than $20 per ton. At this price, the use of 1 per cent of starch as a binder would add only 20 cents per ton to the cost of the briquettes.

The scarcity and high price of slaughterhouse refuse would prohibit its use as a binding material for briquettes, even if the tests with it were otherwise satisfactory, which was not the case.

The tests with coal tars and the different grades of pitch made from these tars indicate that probably in the pitches the most satisfactory binders for the manufacture of briquettes will be found; and that these can be made at such a price as will bring the cost of the binding material used to not more than 50 to 75 cents per ton of briquettes. Briquettes made from a majority of the bituminous coals with a good grade of pitch as a binder are sufficiently strong to bear ordinary handling; they will stand exposure to the weather for a number of years without serious deterioration; and they burn well in the fire. The supply of pitch is already large and can be easily increased. The price now ranges from $9 to $11 per ton. The pitches obtained from different plants and those obtained at different times from the same plant varied considerably, not only in their boiling points but in other respects; and in the case of similar pitches the percentage necessary for the proper working of different coals seemed to vary according to differences in the quality of the coals. It was found to be better to mix with a noncoking coal 10 to 20 per cent of a coking coal, rather than to increase the percentage of pitch.

In the investigation of the asphalts as binding materials, impsonite from Indian Territory was found to be rather unsatisfactory, though in a number of tests with noncoking coals the result was improved by the addition to such coal of from 5 to 10 per cent of impsonite in addition to from 3 to 5 per cent of ordinary pitch or some other binding material. From 4 to 8 per cent of gilsonite and other asphalts from Utah gave fairly satisfactory results as a binder. This material is said to exist in Utah and elsewhere in large quantities, and while the price is at present too high to permit its extensive use as a binder, doubtless should the demand for it in this connection increase the deposits would be opened up to such an extent that it might be sold at lower prices.

Experiments were made with several other asphaltic materials, and though the results were such as to warrant further investigation they were not altogether satisfactory. Asphaltic tar yielded fairly good results as a waterproofing material in briquettes made with starch. Asphaltic materials yielded the best results in waterproofing.

From 4 to 6 per cent of maltha (a liquid asphalt) used as a binder yielded fairly satisfactory results with coking coals. With noncoking coals it was found to be insufficient for the purpose.

Crude petroleums have been tested as binding materials, with satisfactory results. The asphaltic petroleums were used successfully in waterproofing briquettes made with a starch binder, though it is doubtful whether this practice would prove entirely satisfactory in operations on a commercial scale. In the tests the success of the waterproofing was fairly proportional to the amount of asphaltic material in the petroleum. As a binding material the asphaltic petroleum proved even more successful than when used for waterproofing purposes, from 6 to 8 per cent being entirely satisfactory.

The petroleum residuums proved to be successful binding materials somewhat in proportion as the per cent of asphalt in them increased. That obtained from the Gulf Refining Company, of Port Arthur, Tex., was found to melt at a temperature of 100° C., and about 99.38 per cent of it was found to be soluble in carbon disulphide. Another sample of asphaltic petroleum from the Gulf Refining Company flowed at a temperature of 95° C. and of this it was found that carbon disulphide would dissolve 99.88 per cent. From 4 to 6 per cent of this material gave excellent results as a binder for briquettes.

Water-gas tar, which is obtained from illuminating-gas plants, was not tested sufficiently to give satisfactory results, but it is believed that this material could be used as a binder if properly mixed with other somewhat similar materials. It is necessary, after this material is mixed with the coal, that the mixture should be raised to a sufficiently high temperature to liquefy and perhaps even to vaporize the tar.

The water-gas pitch which was furnished by the Barrett Manufacturing Company flowed at a temperature of 92° C. It was found that 4½ to 7 per cent of this pitch, which would be equivalent to from 6 to 8 per cent of coal-tar pitch, would make satisfactory briquettes. The cost of this binder would be from 45 to 65 cents per ton of briquettes.

The wax tailings used in these investigations were obtained from the Standard Oil Company. They melt at a temperature of about 70° C. From 4 to 6 per cent of this material would prove satisfactory in the briquettes. The amount of this material produced in the United States is small and the price is about 6 cents per gallon. This would make the binding material used in a ton of briquettes cost approximately 45 to 60 cents.

Tests made with acid sludge as a binder were not satisfactory. It not only added the unwelcome sulphur, but its binding qualities were very inferior.

Asphalt tar was found unsatisfactory as a binder even when 8 to 12 per cent was used, inasmuch as the briquettes fell to pieces in the fire; but its use for waterproofing when starch or other material had been used as a binder proved fairly satisfactory.

Pintsch-gas tar, produced by heating petroleum oil in iron retorts at a high temperature, was obtainable in so small a quantity that only preliminary tests were made covering its use as a binder and these were only partially satisfactory.

REQUISITES FOR BINDING MATERIALS.

The results of the investigations in the laboratory of the fuel-testing plant and the writer's observations in briquetting plants in other countries point to certain general conclusions concerning the requisites of satisfactory binding materials for use in the manufacture of briquettes.

In the making of coal briquettes the binding work is best performed when the particles of coal are coated and when the void spaces are filled with the binding material. This is best accomplished when the temperature of the mixture before compression is raised sufficiently to liquefy or vaporize the binder.

The relation between the coal and the binder seems to be physical rather than chemical, though it is possible that certain minor chemical changes may accompany the briquetting operation.

The amount of the binding material necessary will therefore depend on the aggregate of the surfaces of the coal particles to be coated, on the void spaces to be filled, and on the general physical and chemical character of the coal. Coking coals require less binder than noncoking coals, and the percentage of binder necessary for the latter coals may, in many cases, be diminished and the quality of the briquette otherwise improved by the previous admixture with them of from 10 to 20 per cent of some coking coal.

Furthermore, when a coal is finely pulverized, a result which frequently follows protracted slacking on exposure to the weather, the briquetting of such material is facilitated by the mixture of a considerable percentage of the same or another coal—preferably a nonslacking coal—crushed to sizes ranging from one-sixteenth inch to one-fourth inch.

The following are mentioned as the more important requisites of a suitable binding material for use in the manufacture of briquettes:

(1) It must be inexpensive, because of the small difference in the United States between the prices of slack or fine coal and those of lump coal. This difference in some regions is practically nothing, as in the Pocahontas coal fields of West Virginia; while in a number of other fields, as in portions of Indiana, Illinois, Arkansas, etc., it may reach $1 or even $1.50 a ton.

(2) It should be capable of abundant production in different parts of the country, in order to avoid the necessity for long transportation.

(3) It should be of such character as to make it easily handled and applied at workable temperatures. If it is used in solid condition, as in the case of pitch, the melting point should not be lower than the temperature of hot summer days, nor ordinarily above that of live steam.

(4) It should hold the briquette together strongly, not only during ordinary handling and transportation, but also during protracted exposure to the weather and while burning. Certain materials, like starch and molasses, yield fairly satisfactory results as long as the briquettes are kept dry and during their consumption by fire; but as these materials are soluble in water, the briquettes in which they are used as a binder go to pieces under the

action of water unless rendered waterproof through the application of other substances. On the other hand some briquettes which remain firm under the action of water crumble when heated because of the fact that the binding material used volatilizes at a low temperature. Even in the coking coals the binder should hold the particles together at least until the coal itself is sufficiently softened to cohere and begin burning.

(5) It should not add appreciably to the ash of the coal nor increase the clinker formation in the ash. It should not give off fumes nor seriously increase the smoke in the burning of the briquettes. It is generally claimed that owing to the more perfect combustion in burning briquettes, less smoke is produced from the coal and binder together than is given off from the consumption of the unbriquetted or natural coal. Binding materials which have a low melting or boiling temperature give off more smoke because of the fact that this smoke originates at a temperature too low for complete combustion. Briquettes, as in the case of lump coal, give off less smoke when the arrangements for proper draft are such as to facilitate combustion.

(6) The binding material should increase, or certainly should not decrease, the heating quality of the coal which is used in the manufacture of the briquettes.

BRIQUETTING WITHOUT THE USE OF BINDING MATERIALS.

In August, 1904, under the writer's supervision, samples of lignite from Lehigh, N. Dak., and from near Rockdale, Tex., were shipped to Magdeburg and Zeitz, Germany, to be used for experiments to determine the feasibility of briquetting these lignites with the German presses. These tests were conducted by the writer. They were entirely successful and the briquettes made with these lignites, after being crushed and dried, subsequently stood the tests applied to the German lignite briquettes, which are extensively used for domestic purposes.

To a portion of the briquettes made at Magdeburg 2 per cent of ordinary coal-tar pitch was added, with the view of determining what, if any, advantage would result from such an addition. Laboratory tests indicated that the briquettes to which this pitch had been added burned more rapidly, with more flame, and at a higher heat efficiency than those without it, and the North Dakota lignite seemed to give off fewer sparks in burning. It is estimated that the cost of manufacturing these briquettes (not including the cost of the lignite) should not exceed 50 cents per ton. The analyses of the lignite briquettes made at Magdeburg are as follows:

Analyses of lignite briquettes made at Magdeburg, Germany.

[Dried before briquetting.]

		From Lehigh, N. Dak.		From Rockdale, Tex.	
		Without pitch or other binder.	With 2 per cent of pitch added.	Without pitch or other binder.	With 2 per cent of pitch added.
Proximate.	Moisture	12.96	11.22	8.88	8.92
	Volatile matter	37.79	38.68	40.92	41.33
	Fixed carbon	38.63	41.11	41.90	42.35
	Ash	10.62	8.99	8.30	7.40
Ultimate.	Sulphur	.75	1.04	.97	1.07
	Hydrogen	4.99	5.09	5.21	5.23
	Carbon	52.88	56.26	59.06	59.61
	Nitrogen	.65	.73	1.15	1.14
	Oxygen	30.11	27.89	25.31	25.55
Calories		4,941	5,332	5,682	5,828
British thermal units		8,894	9,598	10,228	10,490
Moisture in undried sample of lignite as received at Magdeburg		28.87		32.07	

It is proposed to continue these investigations of the lignites until results are obtained which will show how they can be briquetted economically in the manner indicated above and, in general, how they can be utilized most efficiently.

Concerning the possibility of briquetting bituminous coals without binding materials, by raising the temperature, and also concerning the possibility of decreasing the percentage of binding material by raising the temperature of the coals preliminary to briquetting, a number of tests were made by Doctor Mills in the laboratory of the fuel-testing plant at St. Louis, but the results in each case were unsatisfactory, as they failed to indicate the probability of economic success in that direction.

SOME GENERAL CONCLUSIONS.

The successful development of a coal-briquetting industry in the United States will depend on a number of conditions, some of which are variable.

The condition which more than any other has prevented the development of such an industry in this country is the low price of bituminous coal and especially the small difference between the price of the lump coal and that of the slack, or fine coal. Especially is this latter phase of the problem illustrated by the coking coals of Pennsylvania and West Virginia, where much of the slack coal commands a price equal to or approximating that of the lump coal. Much of the lump coal is finally crushed before being manufactured into coke, and the slack coal even has the advantage in not having to be crushed. Furthermore, even where these coals are not used for the manufacture of coke, but are sold for general power purposes, much of the fine coal can be shipped and burned with the lump coal, for the reason that it fuses as soon as it begins to burn, and therefore does not to any serious extent sift down through the grate bars and either clog the draft or escape with the ashes, as is the case with noncoking coals.

In the territory of the noncoking coals the demand for the slack coal is not so great, and it can in some places be bought at less than 50 cents per ton; while at a number of mines large quantities are thrown on the dump as waste, frequently being burned in order to get rid of it.

Perhaps in no country has specialized equipment for burning fine coal been carried so far as it has in the United States, but the results of a number of tests by engineers seem to indicate that with the noncoking coals the use of the finely powdered coal, even in the modern furnace, is a disadvantage rather than a gain, for the reason that this fine material sifts through onto the grates, is ultimately lost with the ashes, and meanwhile prevents a full draft, which is essential to rapid and complete combustion. This is, therefore, one class of material which should be separated from the coarser coals and made into briquettes, provided the price at which these briquettes can be sold is sufficient to more than cover the cost of manufacture.

With anthracite and semianthracite coals the difference between the price of the lump coal and that of the slack is often more than sufficient to cover the cost of manufacturing briquettes, and in such cases there can be no question as to the possibility of establishing a briquetting industry as soon as the proper binding material and briquetting equipment can be provided.

There are still other cases in which it is claimed that the difference between the prices of the lump coal and of the slack are either just sufficient, or scarcely sufficient, to cover the cost of briquette manufacture, but the fact that the briquettes made from this material present certain advantages over the lump coal make them command a sufficiently higher price to provide a margin of profit.

Unfortunately the high cost of the pitch which is generally used as a binding material is one of the barriers now existing in the way of the development of this industry. One of the purposes of the present investigation is to discover, if possible, some cheaper binding material, and the outlook in that direction is encouraging. The cost of manufacturing briquettes in France, Germany, Belgium, and England, including all necessary items

except that of the coal and binding material, is estimated to range from 25 to 50 cents per ton, varying with the local conditions.

Where pitch is used as a binder, as is almost universally the case in each of these countries, its cost for a ton of briquettes may be said to range from 50 to 80 cents. How far this cost may be reduced by the use on a commercial scale of cheaper binders remains to be seen.

The most favorable outlook for the development of this industry in the United States is in connection with the use of briquettes in locomotives and in domestic furnaces and stoves. It can hardly be expected that, at anything approximating existing prices, briquettes can be manufactured for successful use in the ordinary power-plant furnaces of the country.

In connection with the use of briquettes for domestic purposes, the following advantages are claimed:

1. That the briquettes burn with a higher efficiency and with less smoke, because they allow a better circulation of air and the combustion is more complete and more uniform.
2. That the briquettes are cleaner, and that there is less waste in their use.
3. That they burn with more flame (owing to the added combustible binding material) and at higher temperatures.
4. That they occupy less space (by from 5 to 20 per cent) than does the lump coal.
5. That they stand handling and exposure to weather better.
6. That in their storage there is no risk of spontaneous combustion.

A number of these advantages are also claimed for the use of briquettes in locomotives.

SOME CHARACTERISTICS OF GOOD BRIQUETTES.

In view of the great interest existing in the development of a briquetting industry in the United States at the present time and of the numerous efforts toward such development which are being put forth in different parts of the country, it may not be inopportune to introduce here a brief statement of some of the requisites of a briquette intended for general use:

(1) The cost should be but little, if any, in excess of that of lump coal of the same kind as that from which the material in the briquette was derived.

(2) The strength and binding material of the briquette must be such that it will (*a*) bear handling and railway transportation without serious loss from crumbling, (*b*) stand exposure to the weather without serious deterioration, and (*c*) retain its shape in the fire.

(3) Its density should at least equal that of the lump coal from the same mine and, if practicable, should exceed it. It should not absorb more than about 3 per cent of water.

(4) It should ignite readily and burn with a good, intense flame, and as nearly as possible without odor or smoke.

(5) Its heating value should not be less than that of the best lump coal from the same mine. Naturally its heating value can not exceed that of this coal, except that if the binding material used has a higher heat efficiency, this may slightly increase the heat efficiency of the briquette, and the more complete combustion which is claimed for the briquette as compared with the natural coal may still further slightly increase its relative heat efficiency.

(6) Its ash should not exceed that of the best lump coal from the same mine. Whenever the conditions are favorable, the percentage of ash should be reduced by washing the fine coal preliminary to its use in briquette manufacture.

The sizes of briquettes will vary according to the purposes for which they are intended and with other local conditions. In general, it may be said that the larger the briquette the cheaper its manufacture. Some of the English briquettes shipped to South America weigh as much as 20 pounds each. The English briquettes exported from Swansea average about 10 pounds each in weight. The briquettes commonly used on locomotives in France, Belgium, Germany, and other European countries range from about 3 to 10 pounds in weight. The larger briquettes are generally broken into pieces before being thrown into the furnace or fire box, and this always causes more or less waste, but the large size is adopted for original manufacture owing to the smaller cost and the convenience in handling. The

briquettes for domestic use are not usually more than 2 pounds nor less than one-fourth pound in weight. The smaller briquettes are usually of biscuit or lenticular shape, whereas the larger briquettes for railroad use are generally square or prismatic, with slightly rounded edges.

PRELIMINARY TESTS IN BURNING BRIQUETTES ON LOCOMOTIVES.

Two hundred tons of Arkansas semianthracite slack coal from the mines of the Western Coal and Mining Company were made into briquettes for the purpose of preliminary tests concerning their suitability for use in locomotives. Twelve tons of this coal were made, on a Renfrow machine, into biscuit-shaped briquettes averaging about 10 ounces in weight. The remainder was made into briquettes 4½ by 6¾ by 2½ inches, averaging in weight about 3½ pounds. From 6 to 6½ per cent of pitch was used as a binding material in all these briquettes.

After a few tests on a switching engine to determine the best method of firing these briquettes, two tests were made on the locomotive drawing the regular passenger train of the Missouri Pacific Railway from St. Louis to Sedalia, Mo., a distance of 188 miles. On a similar run made by this passenger train, with the same engine and fireman, lump coal was used from the Consolidated Coal Company's mine No. 17, at Collinsville, Ill., this being taken as a good average of the coal ordinarily used by the Missouri Pacific Railway. The water and coal consumed were in each case carefully weighed, but in these preliminary tests no records were made of the steam pressures and temperatures of the feed water.

The engine steamed freely on each of the three tests. No clinkers were formed on the grates or tube sheet with the Illinois bituminous coal. A light clinker was formed over the grates with both runs on the Arkansas coal, which, however, did not interfere with the engine making the required amount of steam. The tube sheet clinkered on the run using Renfrow briquettes, and it was necessary to clean off the clinker at Jefferson City, 125 miles from St. Louis. In both tests with briquettes they burned almost without smoke and were reported as being a satisfactory fuel for locomotives in the service of this railroad. The mechanical engineer of the company, under whose supervision these tests were made, expresses the opinion that the advantages gained in burning the briquettes were more than sufficient to cover the cost of their manufacture.

However, the above tests must be considered as simply preliminary to more careful tests to be made later, and these additional tests must be made at an early date.

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DETAILED REPORT OF TESTS.

The following are the results of tests made on the various samples of coal received from May 1, 1905, to January 1, 1906, arranged alphabetically according to States and showing in succession under the head of each sample all tests made on that sample.

CALIFORNIA NO. 1.

Lignite from Tesla mine, San Francisco and San Joaquin Coal Company, Tesla, Alameda County, Cal.

This sample consisted of run-of-mine lignite, and was shipped under the supervision of E. W. Parker, statistician, United States Geological Survey. It was used in making producer-gas tests Nos. 32, 33, and 34.

Two mine samples (Nos. 1606 and 1607) were taken for chemical analysis at widely separated points in the mine.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1606	1607	1680
Air-drying loss		4.60	4.50	10.40
Proximate.	Moisture	17.59	18.02	18.51
	Volatile matter	41.09	39.22	35.33
	Fixed carbon	23.29	26.39	30.67
	Ash	18.03	16.37	15.49
Ultimate.	Sulphur	2.89	3.07	3.05
	Hydrogen			5.93
	Carbon			47.34
	Nitrogen		.49	.66
	Oxygen			27.53
Calorific value determined:				
	Calories		4,503	4,726
	British thermal units		8,105	

PRODUCER-GAS TESTS.

Test 32, California No. 1.

Duration of test, 42 hours.

Average electrical horsepower		207.4
Average B. T. U. gas, per cubic foot		158.3
Total coal fired	pounds..	23,850

Test 33, California No. 1.

A mixture composed of one-half Tesla lignite and one-half "front-end" cinders from locomotives at San Francisco, furnished by the Southern Pacific Company, was fed into the gas producer under normal conditions, and the test continued for several hours, but it was found impossible to keep up a supply of gas that would operate the engine under ordinary load. The analyses of the lignite, cinders, and resulting gas are given below.

Test 34, California No. 1.

A mixture of two-thirds Tesla lignite and one-third "front-end" cinders, as in test 33, was used in this test.

Duration of test, 24 hours.

Average electrical horsepower		206.2
Average B. T. U. gas, per cubic foot		132.6
Total mixture fired	pounds..	11,850

COAL OR MIXTURE CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 32.			Test 34.		
	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:						
Available for outside purposes	2.91	2.41	1.96	2.50	2.17	1.79
Developed at switch board	2.74	2.26	1.84	2.40	2.08	1.71
Per brake horsepower:						
Available for outside purposes	2.48	2.05	1.66	2.13	1.85	1.52
Developed at engine	2.33	1.92	1.56	2.04	1.77	1.46
Equivalent used by producer plant.						
Per electrical horsepower:						
Available for outside purposes	3.06	2.53	2.06	.....	.....	.....
Developed at switch board	2.88	2.38	1.94	.....	.....	.....
Per brake horsepower:						
Available for outside purposes	2.60	2.15	1.75	.....	.....	.....
Developed at engine	2.45	2.02	1.65	.....	.....	.....

ANALYSES.

	Test 32.	Test 33.		Test 34.	
		Lignite.	Cinders.	Lignite.	Cinders.
Coal.					
Moisture	17.36	17.41	3.50	17.41	3.50
Volatile matter	38.41	36.06	6.36	36.06	6.36
Fixed carbon	28.76	30.87	74.93	30.87	74.93
Ash	15.47	15.66	15.21	15.66	15.21
	100.00	100.00	100.00	100.00	100.00
Sulphur	2.96	3.10	.63	3.10	.63

	Test 32.	Test 33.	Test 34.
Gas by volume.			
Carbon dioxide (CO_2)	10.0	11.2	9.7
Carbon monoxide (CO)	19.2	17.4	18.1
Hydrogen (H_2)	11.4	8.3	7.9
Methane (CH_4)	3.9	2.7	3.0
Nitrogen (N_2)	55.4	60.4	61.3
Oxygen (O_2)	.1	.....	.....
	100.0	100.0	100.0

ILLINOIS NO. 6.

Bituminous coal from Coffeen mine, Clover Leaf Coal Company, Coffeen, Montgomery County, Ill., on the Toledo, St. Louis and Western Railroad.

One sample of this coal was shipped to the testing plant in 1904, and of this sample some coal remained after the plant shut down at the end of that year. This coal was used in making steaming test No. 106.

An additional sample was shipped under the supervision of Inspector J. W. Groves, consisting of run-of-mine coal, which was used in making washing test No. 101 and producer gas test No. 35.

One mine sample was taken from this mine by the inspector for chemical analysis. This was cut from the face of the second right entry, 1,500 feet northwest of the shaft.

CHEMICAL ANALYSES.[a]

		Mine sample.	Car sample.
Laboratory number		1661	1702
Air-drying loss		6.60	8.10
Proximate.	Moisture	12.90	11.93
	Volatile matter	33.77	29.99
	Fixed carbon	42.25	43.90
	Ash	11.08	14.18
Ultimate.	Sulphur	3.78	4.29
	Hydrogen	.....	5.21
	Carbon	.....	56.94
	Nitrogen	.....	1.01
	Oxygen	.....	18.37
Calorific value determined:			
	Calories	6,031	5,724
	British thermal units	10,856	10,303

[a] For analyses of mine samples taken during the Exposition period see Bull. U. S. Geol. Survey No. 261, 1905, p. 37.

STEAMING TEST.

Test 106, Illinois No. 6, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 4.7 per cent; ½ inch to 1 inch, 19.3 per cent; ¼ inch to ½ inch, 21.5 per cent; under ¼ inch, 54.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 106.
Heating value of coal ..... B. T. U. per pound dry coal..	12,762
Force of draft:	
Under stack damper ..... inch water..	.55
Above fire ..... do....	.25
Furnace temperature ..... °F..	2,213
Dry coal used per square foot of grate surface per hour ..... pounds..	25.94
Equivalent water evaporated per square foot of water-heating surface per hour ..... do....	3.39
Percentage of rated horsepower of boiler developed	95.3
Water apparently evaporated per pound of coal as fired ..... pounds..	4.69
Water evaporated from and at 212° F.:[a]	
Per pound of coal as fired ..... do....	5.56
Per pound of dry coal ..... do....	6.56
Per pound of combustible ..... do....	7.45
Efficiency of boiler, including grate ..... per cent..	49.64
Coal as fired:	
Per indicated horsepower hour ..... pounds..	5.09
Per electrical horsepower hour ..... do....	6.28
Dry coal:	
Per indicated horsepower hour ..... do....	4.31
Per electrical horsepower hour ..... do....	5.32

[a] A better evaporation would have been obtained if boilers and gas-sampling apparatus had been in better condition, as they were later.

ANALYSES.

	Test 106.		Test 106.
Proximate.		*Ultimate.*	
Moisture	15.33	Carbon[a]	70.44
Volatile matter	33.76	Hydrogen[a]	4.63
Fixed carbon	42.18	Oxygen[a]	9.66
Ash	8.73	Nitrogen[a]	1.28
	100.00	Sulphur	3.68
Sulphur	3.12	Ash	10.31
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 35, Illinois No. 6 B.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 60 hours.

Average electrical horsepower	206.7
Average B. T. U. gas, per cubic foot	152.0
Total coal fired, pounds	23,400

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 35.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	2.00	1.77	1.45
Developed at switch board	1.89	1.67	1.37
Per brake horsepower:			
Available for outside purposes	1.70	1.50	1.23
Developed at engine	1.61	1.42	1.16
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.14	1.89	1.55
Developed at switch board	2.02	1.79	1.46
Per brake horsepower:			
Available for outside purposes	1.82	1.61	1.31
Developed at engine	1.72	1.52	1.25

ANALYSES.

	Test 35.		Test 35.
Coal.		*Gas by volume.*	
Moisture	11.47	Carbon dioxide (CO_2)	7.8
Volatile matter	31.67	Carbon monoxide (CO)	20.9
Fixed carbon	40.78	Hydrogen (H_2)	9.0
Ash	16.08	Methane (CH_4)	3.7
	100.00	Nitrogen (N_2)	58.5
Sulphur	4.59	Oxygen (O_2)	.1
			100.0

WASHING TEST.

Test 101, Illinois No. 6.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	14,710
Washed coal	do....	13,586
Refuse	do....	1,124

ANALYSES.

	Test 101.	
	Raw coal.	Washed coal.
Moisture	14.43	15.23
Volatile matter	29.48	.....
Fixed carbon	42.81	.....
Ash	13.28	8.64
Sulphur	4.01	3.30

ILLINOIS NO. 7.

Bituminous coal from mine No. 2, Lumaghi Coal Company, near Collinsville, Madison County, Ill., on the Vandalia Railroad.

Four lots of coal were shipped for testing from this mine. One consisted of slack which had been passed through a 1-inch mesh screen; this lot is designated as Illinois No. 7 A and was used in making producer test No. 26. Sample Illinois No. 7 B consisted of nut coal which had passed over a 1-inch mesh screen and was used in making producer-gas test No. 27. These two lots were shipped under the supervision of Inspector J. S. Burrows. Sample Illinois No. 7 C consisted of another car of slack, which was used in making washing test No. 104, steaming test No. 122, steaming test on washed coal No. 129, and producer-gas test No. 38. This car was not inspected, as it was slack coal. Sample Illinois No. 7 D consisted of run-of-mine coal and was shipped under the supervision of Inspector J. W. Groves. It was used in making washing test No. 108, coking tests Nos. 1 and 4, and steaming tests Nos. 142, 143, and 146.

Two mine samples were collected in this mine for chemical analysis. No. 1608 was taken at the face of room 17, north entry, and No. 1609 at the face of room 14, south entry.

CHEMICAL ANALYSES.

		Mine samples.		Car sample B	Car sample D.
Laboratory number		[a]1608	[a]1609	1611	1780
Air-drying loss		5.90	5.90	5.00	3.50
Proximate.	Moisture	12.27	11.87	11.46	10.86
	Volatile matter	37.22	36.57	34.98	36.24
	Fixed carbon	39.16	39.98	36.25	39.75
	Ash	11.35	11.58	17.31	13.18
	Sulphur	4.66	4.75	4.40	4.53
Ultimate.	Hydrogen	.....	.....	5.05	5.35
	Carbon	.....	.....	54.56	58.59
	Nitrogen	.....	1.02	.94	.99
	Oxygen	.....	.....	17.74	17.37
Calorific value determined:					
	Calories	.....	5,982	5,570	6,009
	British thermal units	.....	10,768	10,026	10,816

[a] Samples secured by J. S. Burrows.

STEAMING TESTS.

Test 122, Illinois No. 7 C.

Size as shipped, slack. Size as used, ½ inch to 1 inch, 12.8 per cent; ¼ inch to ½ inch, 18.3 per cent; under ¼ inch, 68.9 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

Test 129, Illinois No. 7 C.

Size as shipped, slack. Size as used, ½ inch to 1 inch, 10.46 per cent; ¼ inch to ½ inch, 25.50 per cent; under ¼ inch, 64.04 per cent. Washed. Duration of test, 8.35 hours. Kind of grate, plain.

Test 142, Illinois No. 7 D.

Size as shipped, run of mine. Size as used, over 1 inch, 33.5 per cent; ½ inch to 1 inch, 23.3 per cent; ¼ inch to ½ inch, 15.0 per cent; under ¼ inch, 28.2 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 143, Illinois No. 7 D.

Size as shipped, run of mine. Size as used, over 1 inch, 32.1 per cent; ½ inch to 1 inch, 22.0 per cent; ¼ inch to ½ inch, 15.6 per cent; under ¼ inch 30.3 per cent. Duration of test, 10.0 hours. Kind of grate, plain.

Test 146, Illinois No. 7 D.

Size as shipped, run of mine. Size as used, over 1 inch, 24.3 per cent; ½ inch to 1 inch, 23.3 per cent; ¼ inch to ½ inch, 18.1 per cent; under ¼ inch, 34.3 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 122.	Test 129.	Test 142.	Test 143.	Test 146.
Heating value of coal.....B. T. U. per pound dry coal..	9,999	12,730	11,673	11,212	11,088
Force of draft:					
Under stack damper.....inch water..	0.58	0.55	0.60	0.58	0.61
Above fire.....do....	.30	.24	.16	.18	.22
Furnace temperature.....°F.	.....	.....	.....	.....	.....
Dry coal used per square foot of grate surface per hour, pounds.....	20.08	19.92	20.07	18.74	20.21
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.19	3.19	2.97	2.69	2.68
Percentage of rated horsepower of boiler developed.....	61.4	89.6	83.3	75.5	75.2
Water apparently evaporated per pound of coal as fired, pounds.....	4.71	5.75	5.73	5.59	5.68
Water evaporated from and at 212° F.:					
Per pound of coal as fired.....pounds..	5.44	6.70	6.65	6.46	6.64
Per pound of dry coal.....do....	6.08	8.02	7.42	7.20	7.40
Per pound of combustible.....do....	8.97	9.17	9.25	9.27	9.80
Efficiency of boiler, including grate.....per cent..	58.71	60.84	61.39	62.01	64.45
Coal as fired:					
Per indicated horsepower hour.....pounds..	5.20	4.22	4.25	4.38	4.26
Per electrical horsepower hour.....do....	6.42	5.21	5.25	5.40	5.26
Dry coal:					
Per indicated horsepower hour.....do....	4.65	3.53	3.81	3.93	3.82
Per electrical horsepower hour.....do....	5.74	4.36	4.70	4.85	4.72

ANALYSES.

	Test 122.	Test 129.	Test 142.	Test 143.	Test 146.
Proximate.					
Moisture.....	10.54	16.45	10.38	10.29	10.29
Volatile matter.....	31.18	34.43	34.33	32.34	32.16
Fixed carbon.....	32.98	40.18	39.08	38.95	38.35
Ash.....	25.30	8.94	16.21	18.42	19.20
	100.00	100.00	100.00	100.00	100.00
Sulphur.....	4.18	3.22	4.28	4.66	5.01

ANALYSES—continued.

	Test 122.	Test 129.	Test 142.	Test 143.	Test 146.
Ultimate.					
Carbon [a]	54.93	70.00	63.24	60.90	59.86
Hydrogen [a]	3.88	4.95	4.49	4.31	4.24
Oxygen [a]	7.31	9.33	8.33	8.02	7.91
Nitrogen [a]	.92	1.16	1.07	1.04	1.01
Sulphur	4.67	3.86	4.78	5.20	5.58
Ash	28.29	10.70	18.09	20.53	21.40
	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 26, Illinois No. 7 A.

Size as shipped, slack. Size as used, not determined. Duration of test, 11½ hours.

Average electrical horsepower..... 138.6
Average B. T. U. gas, per cubic foot..... 109.3
Total coal fired, pounds..... 7,350

Test 27, Illinois No. 7 B.

Size as shipped, nut and pea. Size as used, not determined. Duration of test, 30 hours.

Average electrical horsepower..... 204.1
Average B. T. U. gas, per cubic foot..... 138.6
Total coal fired, pounds..... 13,650

Test 38, Illinois No. 7C.

Size as shipped, slack. Size as used, not determined. Duration of test, 33 hours.

Average electrical horsepower..... 174.8
Average B. T. U. gas, per cubic foot..... 120.2
Total coal fired, pounds..... 15,750

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 26.			Test 27.			Test 38.		
	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:									
Available for outside purposes	4.98	4.35	3.27	2.33	2.06	1.65	2.93	2.63	2.08
Developed at switch board	4.69	4.09	3.07	2.23	1.97	1.58	2.73	2.45	1.94
Per brake horsepower:									
Available for outside purposes	4.24	3.69	2.78	1.98	1.75	1.40	2.49	2.24	1.77
Developed at engine	3.98	3.47	2.61	1.89	1.67	1.34	2.32	2.09	1.65
Equivalent used by producer plant.									
Per electrical horsepower:									
Available for outside purposes	5.25	4.58	3.45	2.52	2.22	1.78	3.12	2.80	2.21
Developed at switch board	4.94	4.30	3.24	2.41	2.12	1.70	2.91	2.61	2.06
Per brake horsepower:									
Available for outside purposes	4.46	3.89	2.93	2.14	1.89	1.51	2.65	2.38	1.88
Developed at engine	4.20	3.66	2.76	2.05	1.81	1.45	2.47	2.22	1.75

ANALYSES.

	Test 26.	Test 27.	Test 38.		Test 26.	Test 27.	Test 38.
Coal.				*Gas by volume.*			
Moisture	12.76	11.92	10.08	Carbon dioxide (CO_2)	11.9	10.9	11.2
Volatile matter	32.35	33.95	32.71	Carbon monoxide (CO)	10.7	12.6	14.5
Fixed carbon	33.37	36.67	38.26	Hydrogen (H_2)	7.9	9.4	7.7
Ash	21.52	17.46	18.95	Methane (CH_4)	3.8	4.9	3.2
	100.00	100.00	100.00	Nitrogen (N_2)	65.7	62.1	63.4
Sulphur	3.82	4.15	4.15	Oxygen (O_2)	.....	.1	.....
					100.0	100.0	100.0

WASHING TESTS.

Test 104, Illinois No. 7 C.

Size as shipped, slack. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	15,809
Washed coal	do	11,238
Refuse	do	4,571

Test 108, Illinois No. 7 D.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	14,000
Washed coal	do	11,790
Refuse	do	2,210

ANALYSES.

	Test 104.		Test 108.	
	Raw coal.	Washed coal.	Raw coal.	Washed coal.
Moisture	10.69	16.64	10.83	12.45
Volatile matter	33.08	.....	36.24	.....
Fixed carbon	36.14	.....	39.75	.....
Ash	20.09	8.59	13.18	9.30
Sulphur	4.06	3.25	4.53	3.65

COKING TESTS.

Test 1, Illinois No. 7 D.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 43 hours.

Coal charged	pounds	8,000
Coke produced	do	3,907
Breeze produced	do	452
Coke produced	per cent	48.84
Breeze produced	do	5.65
Total percentage yield		54.49

Remarks.—Good, hard coke. Sulphur and ash too high. First charge after ovens put in commission. One-inch black butts on coke. More seasoned ovens would probably give better results.

Test 4, Illinois No. 7 D, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 65 hours.

Coal charged	pounds	10,000
Coke produced	do	5,200
Breeze produced	do	260
Coke produced	per cent	52.00
Breeze produced	do	2.60
Total percentage yield		54.60

Remarks.—Light-gray and silvery color. Good, strong coke. Ash reduced by washing. Sulphur reduction small.

ANALYSES.

	Test 1.		Test 4.	
	Coal.	Coke.	Coal.	Coke.
Moisture	10.88	2.26	12.45	1.04
Volatile matter	35.27	1.86	36.17	.61
Fixed carbon	38.44	72.68	42.08	82.10
Ash	15.41	23.20	9.30	16.25
Sulphur	4.53	3.95	3.64	3.24

ILLINOIS NO. 8.

Bituminous coal from Paisley mine, Dering Coal Company, Paisley, Montgomery County, Ill., on the Big Four Railroad.

This sample consisted of nut coal. It was shipped before the corps of inspectors was organized, and consequently the loading of the car was not supervised by a representative of the plant. This sample was used in making steaming tests Nos. 101 and 102 and producer-gas test No. 29.

No mine samples have as yet been taken from this mine, but before the final report of the testing plant is prepared the mine will be examined and the samples obtained.

CHEMICAL ANALYSES.

		Car sample.
Laboratory number		1627
Air-drying loss		4.40
Proximate.	Moisture	13.20
	Volatile matter	34.33
	Fixed carbon	39.94
	Ash	12.53
Ultimate.	Sulphur	4.47
	Hydrogen	5.51
	Carbon	57.25
	Nitrogen	1.02
	Oxygen	19.22
Calorific value determined:		
	Calories	5,841
	British thermal units	10,514

STEAMING TESTS.

Test 101, Illinois No. 8.

Size as shipped, nut. Size as used, over 1 inch, 58 per cent; ½ inch to 1 inch, 21.9 per cent; ¼ inch to ½ inch, 8.7 per cent; under ¼ inch, 11.4 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 102, Illinois No. 8.

Size as shipped, nut. Size as used, over 1 inch 50.4 per cent; ½ inch to 1 inch, 25.5 per cent; ¼ inch to ½ inch, 10.6 per cent; under ¼ inch, 13.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 101.	Test 102.
Heating value of coal.....B. T. U. per pound dry coal..	12,047	12,002
Force of draft:		
Under stack damper.....inch water..	0.63	0.63
Above fire.....do....	.31	.25
Furnace temperature.....°F..	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	28.82	28.36
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.21	3.62
Percentage of rated horsepower of boiler developed	90.1	101.5
Water apparently evaporated per pound of coal as fired.....pounds..	4.56	4.71
Water evaporated from and at 212 °F.: [a]		
Per pound of coal as fired.....do....	5.39	5.58
Per pound of dry coal.....do....	6.22	6.39
Per pound of combustible.....do....	7.75	7.70
Efficiency of boiler, including grate.....per cent..	49.86	51.41
Coal as fired:		
Per indicated horsepower hour.....do....	5.25	5.07
Per electrical horsepower hour.....do....	6.48	6.26
Dry coal:		
Per indicated horsepower hour.....do....	4.55	4.42
Per electrical horsepower hour.....do....	5.61	5.46

[a] A better evaporation would have been obtained if boilers and gas-sampling apparatus had been in better condition, as they were later.

ANALYSES.

	Test 101.	Test 102.		Test 101.	Test 102.
Proximate.			*Ultimate.*		
Moisture	13.31	12.67	Carbon [a]	65.13	65.31
Volatile matter	34.61	34.23	Hydrogen [a]	4.59	4.61
Fixed carbon	39.39	40.00	Oxygen [a]	8.53	8.56
Ash	12.69	13.10	Nitrogen [a]	1.16	1.16
	100.00	100.00	Sulphur	5.95	5.36
Sulphur	5.16	4.68	Ash	14.64	15.00
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 29, Illinois No. 8.

Size as shipped, nut. Size as used, not determined. Duration of test, 42 hours.

Average electrical horsepower	208.0
Average B. T. U. gas, per cubic foot	147.0
Total coal fired, pounds	16,050

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 29.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.93	1.68	1.46
Developed at switch board	1.84	1.60	1.39
Per brake horsepower:			
Available for outside purposes	1.64	1.43	1.24
Developed at engine	1.56	1.36	1.18
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.08	1.81	1.57
Developed at switch board	1.98	1.72	1.50
Per brake horsepower:			
Available for outside purposes	1.77	1.54	1.34
Developed at engine	1.68	1.47	1.27

ANALYSES.

	Test 29.		Test 29.
Coal.		*Gas by volume.*	
Moisture	12.91	Carbon dioxide (CO_2)	8.0
Volatile matter	33.83	Carbon monoxide (CO)	19.8
Fixed carbon	41.67	Hydrogen (H_2)	10.3
Ash	11.59	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	58.7
Sulphur	4.64	Oxygen (O_2)	0.1
			100.0

ILLINOIS NO. 9.

Bituminous coal from mine No. 2, Mount Olive and Staunton Coal Company, Staunton, Macoupin County, Ill., on the Litchfield and Madison Railroad.

Two separate samples of coal were shipped from this mine under the supervision of Inspector J. S. Burrows. One sample consisted of run-of-mine coal and is called Illinois No. 9 A. The following tests were made on this sample: Washing test No. 102, steaming tests Nos. 103, 104, and 105, and steaming test on washed coal No. 113. The second sample, designated as Illinois No. 9 B, consisted of lump coal and was used in making steaming test No. 121 and producer-gas test No. 28.

Two samples for chemical analysis were taken in this mine from two widely separated points as follows: No. 1625 from the face of room 11 off the first entry north; No. 1626 from the face of the main air course.

CHEMICAL ANALYSES.

		Mine samples.		Car sample A.	Car sample B.
Laboratory number		1625	1626	1635	1639
Air-drying loss		7.70	7.70	9.00	10.10
Proximate.	Moisture	13.29	15.27	13.54	13.72
	Volatile matter	37.07	36.19	35.69	36.24
	Fixed carbon	40.74	39.34	40.03	39.72
	Ash	8.90	9.20	10.74	10.32
Ultimate.	Sulphur	4.12	3.70	4.03	3.96
	Hydrogen	.....	.....	5.71	5.74
	Carbon	.....	.....	58.69	58.95
	Nitrogen	.....	.....	.95	.98
	Oxygen	.....	.....	19.88	20.05
Calorific value determined:					
Calories		6,201	.....	6,004	6,039
British thermal units		11,162	.....	10,807	10,870

STEAMING TESTS.

Test 103, Illinois No. 9 A.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 10.02 hours. Kind of grate, plain.

Test 104, Illinois No. 9 A.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 9.9 hours. Kind of grate, plain.

Test 105, Illinois No. 9 A.

Size as shipped, run of mine. Size as used, over 1 inch, 33.3 per cent; ½ inch to 1 inch, 26.0 per cent; ¼ inch to ½ inch, 15.8 per cent; under ¼ inch, 24.9 per cent. Duration of test, 10.03 hours. Kind of grate, plain.

Test 113, Illinois No. 9 A, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 24.6 per cent; ½ inch to 1 inch, 27.8 per cent; ¼ inch to ½ inch, 20.4 per cent; under ¼ inch, 27.2 per cent. Duration of test, 9.98 hours. Kind of grate, rocking.

Test 121, Illinois No. 9 B.

Size as shipped, lump. Size as used, over 1 inch 35.7 per cent; ½ inch to 1 inch, 29.1 per cent; ¼ inch to ½ inch, 15.0 per cent; under ¼ inch, 20.2 per cent. Duration of test, 9.93 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 103.	Test 104.	Test 105.	Test 113.	Test 121.
Heating value of coal..B. T. U. per pound dry coal.	12,506	12,483	12,555	12,947	12,438
Force of draft:					
Under stack damper.....inch water..	0.56	0.37	0.66	0.50	0.59
Above fire.....do....	.27	.19	.25	.20	.19
Furnace temperature.....°F..	2,218	2,155	2,220	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	26.53	23.22	30.26	25.60	26.60
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.61	3.01	4.08	3.05	3.57
Percentage of rated horsepower of boiler developed.	101.1	84.4	114.3	85.6	100.0
Water apparently evaporated per pound of coal as fired.....pounds..	5.06	4.85	4.99	4.84	5.72
Water evaporated from and at 212° F.: [a]					
Per pound of coal as fired.....do....	5.94	5.70	5.93	5.68	6.69
Per pound of dry coal.....do....	6.81	6.50	6.75	6.66	7.49
Per pound of combustible.....do....	7.87	7.63	7.79	7.50	8.83
Efficiency of boiler, including grate.....per cent..	52.59	50.28	51.92	49.67	58.15
Coal as fired:					
Per indicated horsepower hour.....pounds..	4.76	4.96	4.77	4.98	4.23
Per electrical horsepower hour.....do....	5.88	6.12	5.89	6.15	5.22
Dry coal:					
Per indicated horsepower hour.....do....	4.15	4.35	4.19	4.25	3.77
Per electrical horsepower hour.....do....	5.13	5.37	5.17	5.24	4.66

[a] A better evaporation would have been obtained if boilers and gas-sampling apparatus had been in better condition, as they were later.

ANALYSES.

	Test 103.	Test 104.	Test 105.	Test 113.	Test 121.
Proximate.					
Moisture	12.76	12.21	12.10	14.66	10.70
Volatile matter	36.12	36.38	36.23	36.71	35.84
Fixed carbon	40.78	40.27	41.05	41.19	41.82
Ash	10.34	11.14	10.62	7.44	11.64
	100.00	100.00	100.00	100.00	100.00
Sulphur	3.94	3.89	4.08	3.34	4.11
Ultimate.					
Carbon [a]	68.45	67.83	68.17	71.54	67.42
Hydrogen [a]	4.92	4.88	4.89	5.13	4.83
Oxygen [a]	9.16	9.08	9.13	9.55	8.99
Nitrogen [a]	1.10	1.09	1.10	1.15	1.12
Sulphur	4.52	4.43	4.64	3.91	4.60
Ash	11.85	12.69	12.07	8.72	13.04
	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 28, Illinois No. 9 B.

Size as shipped, lump. Size as used, not determined. Duration of test, 60 hours.

Average electrical horsepower	208.0
Average B. T. U. gas, per cubic foot	143.7
Total coal fired, pounds	23,700

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 28.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.99	1.76	1.53
Developed at switch board	1.90	1.67	1.45
Per brake horsepower:			
Available for outside purposes	1.70	1.49	1.30
Developed at engine	1.61	1.42	1.23
Equivalent used by producer.			
Per electrical horsepower:			
Available for outside purposes	2.11	1.86	1.62
Developed at switch board	2.01	1.77	1.54
Per brake horsepower:			
Available for outside purposes	1.79	1.58	1.37
Developed at engine	1.71	1.50	1.31

ANALYSES.

	Test 28.		Test 28.
Coal.		*Gas by volume.*	
Moisture	11.99	Carbon dioxide (CO_2)	8.9
Volatile matter	35.90	Carbon monoxide (CO)	16.0
Fixed carbon	40.63	Hydrogen (H_2)	9.4
Ash	11.48	Methane (CH_4)	5.1
	100.00	Nitrogen (N_2)	60.5
Sulphur	4.92	Oxygen (O_2)	0.1
			100.0

WASHING TEST.

Test 102, Illinois No. 9 A.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	18,000
Washed coal	do....	13,920
Refuse	do....	4,080

ANALYSES.

	Test 102.	
	Raw coal.	Washed coal.
Moisture	13.54	15.65
Volatile matter	35.69	.....
Fixed carbon	40.03	.....
Ash	10.74	7.57
Sulphur	4.03	3.38

ILLINOIS NO. 10.

Bituminous coal from West Frankfort mine, Dering Coal Company, West Frankfort, Franklin County, Ill., on the Chicago and Eastern Illinois Railroad.

This sample consisted of one car of slack coal. It was shipped without inspection, as the corps of inspectors was not organized at the time the coal was asked for. The following tests were made on this sample: Washing test No. 103, steaming tests Nos. 107, 108, 109, and 110, steaming test on washed coal No. 114, and producer-gas test No. 31.

No mine samples have as yet been obtained from this mine.

CHEMICAL ANALYSES.

		Car sample.
Laboratory number		1648
Air-drying loss		6.90
Proximate.	Moisture	9.50
	Volatile matter	31.98
	Fixed carbon	47.08
	Ash	11.44
Ultimate.	Sulphur	1.45
	Hydrogen	5.31
	Carbon	63.83
	Nitrogen	1.36
	Oxygen	16.61
Calorific value determined:		
	Calories	6,392
	British thermal units	11,506

STEAMING TESTS.

Test 107, Illinois No. 10.

Size as shipped, slack. Size as used, over 1 inch, 2.9 per cent; ½ inch to 1 inch, 23.1 per cent; ¼ inch to ½ inch, 26.4 per cent; under ¼ inch, 47.6 per cent. Duration of test, 10.17 hours. Kind of grate, plain.

Test 108, Illinois No. 10.

Size as shipped, slack. Size as used, over 1 inch, 7.6 per cent; ½ inch to 1 inch, 19.2 per cent; ¼ inch to ½ inch, 21.1 per cent; under ¼ inch, 52.1 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 109, Illinois No. 10.

Size as shipped, slack. Size as used, over 1 inch, 22.8 per cent; ½ inch to 1 inch, 30.1 per cent; ¼ inch to ½ inch, 17.3 per cent; under ¼ inch, 29.8 per cent. Duration of test, 9.98 hours. Kind of grate, rocking.

Test 110, Illinois No. 10.

Size as shipped, slack. Size as used, over 1 inch, 19.2 per cent; ½ inch to 1 inch, 32.6 per cent; ¼ inch to ½ inch, 18.4 per cent; under ¼ inch, 29.8 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 114, Illinois No. 10, washed.

Size as shipped, slack. Size as used, over 1 inch, 12.8 per cent; ½ inch to 1 inch, 27.5 per cent; ¼ inch to ½ inch, 23.4 per cent; under ¼ inch, 36.3 per cent. Duration of test, 10.05 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 107.	Test 108.	Test 109.	Test 110.	Test 114.
Heating value of coal. B. T. U. per pound dry coal	12,429	12,685	12,373	12,929	13,545
Force of draft:					
Under stack damper....inch water	0.59	0.42	0.51	0.45	0.51
Above fire....do	.32	.21	.29	.26	.21
Furnace temperature....°F	2,229				
Dry coal used per square foot of grate surface per hour....pounds	21.00	22.24	21.46	20.66	24.23
Equivalent water evaporated per square foot of water-heating surface per hour....pounds	3.20	3.13	2.96	2.48	3.52
Percentage of rated horsepower of boiler developed	89.9	87.6	83.0	69.6	98.7
Water apparently evaporated per pound of coal as fired....pounds	5.73	5.41	5.83	5.16	6.07
Water evaporated from and at 212° F.:[a]					
Per pound of coal as fired....do	6.76	6.39	6.90	6.08	7.16
Per pound of dry coal....do	7.65	7.04	7.70	6.71	8.11
Per pound of combustible....do	9.17	8.28	9.52	8.05	8.94
Efficiency of boiler, including grate....per cent	59.44	53.60	60.10	50.12	57.82
Coal as fired:					
Per indicated horsepower hour....pounds	4.18	4.43	4.10	4.65	3.95
Per electrical horsepower hour....do	5.16	5.46	5.06	5.74	4.88
Dry coal:					
Per indicated horsepower hour....do	3.70	4.02	3.67	4.21	3.49
Per electrical horsepower hour....do	4.56	4.96	4.53	5.20	4.30

[a] A better evaporation would have been obtained if boilers and gas-sampling apparatus had been in better condition, as they were later.

ANALYSES.

	Test 107.	Test 108.	Test 109.	Test 110.	Test 114.
Proximate.					
Moisture	11.62	9.29	10.32	9.29	11.67
Volatile matter	30.59	31.24	50.01	32.54	32.37
Fixed carbon	44.93	47.84	46.27	48.11	49.87
Ash	12.86	11.63	13.40	10.06	6.09
	100.00	100.00	100.00	100.00	100.00
Sulphur	1.45	1.44	1.46	1.40	1.22

ANALYSES—continued.

	Test 107.	Test 108.	Test 109.	Test 110.	Test 114.
Ultimate.					
Carbon[a]	68.93	70.38	68.61	71.87	75.42
Hydrogen[a]	4.59	4.69	4.57	4.78	5.03
Oxygen[a]	8.86	9.06	8.83	9.23	9.67
Nitrogen[a]	1.43	1.46	1.42	1.49	1.61
Sulphur	1.64	1.59	1.63	1.54	1.38
Ash	14.55	12.82	14.94	11.09	6.89
	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 31, Illinois No. 10.

Size as shipped, slack. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	207.5
Average B. T. U. gas, per cubic foot	140.7
Total coal fired.....pounds..	15,600

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 31.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.60	1.46	1.29
Developed at switch board	1.50	1.38	1.22
Per brake horsepower:			
Available for outside purposes	1.36	1.24	1.10
Developed at engine	1.28	1.17	1.03
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.69	1.54	1.36
Developed at switch board	1.59	1.45	1.28
Per brake horsepower:			
Available for outside purposes	1.44	1.31	1.16
Developed at engine	1.35	1.23	1.09

ANALYSES.

	Test 31.		Test 31.
Coal.		*Gas by volume.*	
Moisture	8.57	Carbon dioxide (CO_2)	9.0
Volatile matter	32.31	Carbon monoxide (CO)	18.5
Fixed carbon	48.45	Hydrogen (H_2)	11.5
Ash	10.67	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	57.9
Sulphur	1.35		100.00

WASHING TEST.

Test 103, Illinois No. 10.

Size as shipped, slack. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	14,710
Washed coal	do....	12,795
Refuse	do....	1,915

ANALYSES.

	Test 103.	
	Raw coal.	Washed coal.
Moisture	9.50	11.86
Volatile matter	31.98	.....
Fixed carbon	47.08	.....
Ash	11.44	6.67
Sulphur	1.45	1.38

ILLINOIS NO. 11.

Bituminous coal from Daw's shaft, St. Louis and Big Muddy Coal Company, near Carterville, Williamson County, Ill., on the Illinois Central Railroad.

Four samples of coal were shipped as follows: Illinois No. 11 A, one-half screenings and one-half egg coal; Illinois No. 11 B, one-half run-of-mine and one-half lump coal; Illinois No. 11 C, one-half No. 4 washed coal and one-half No. 5 washed coal; Illinois No. 11 D, No. 3 washed coal. These samples were shipped under the supervision of J. S. Burrows, and were used in making the following tests: Illinois No. 11 A, steaming tests Nos. 137, 138, 139, and 141, and producer-gas test No. 30; Illinois No. 11 B, steaming tests Nos. 111, 112, 115, 116, 117, 118, and 119; Illinois No. 11 C, steaming test No. 120, and producer-gas test No. 36; Illinois No. 11 D, coking test No. 5, and producer-gas tests Nos. 42 and 48.

Two mine samples were taken in this mine, but one of them was lost in transit. The one received at the laboratory (No. 1634) was cut from the face of the north entry off the straight west heading.

CHEMICAL ANALYSES.

		Mine sample.	Car sample A.	Car sample B.	Car sample C.
Laboratory number		1634	1654	1660	1718
Air-drying loss		4.90	4.80	5.80	6.40
Proximate.	Moisture	8.30	7.76	8.86	8.61
	Volatile matter	33.75	31.44	31.25	32.40
	Fixed carbon	48.69	50.19	48.23	51.33
	Ash	9.26	10.61	11.66	7.66
Ultimate.	Sulphur	2.82	1.97	2.46	1.65
	Hydrogen	.....	5.14	5.24	5.38
	Carbon	.....	66.55	64.29	68.14
	Nitrogen	.....	1.32	1.29	1.34
	Oxygen	.....	14.41	15.06	15.83
Calorific value determined:					
	Calories	6,666	6,643	6,501	6,798
	British thermal units	11,999	11,957	.....	12,236

STEAMING TESTS.

Test 137, Illinois No. 11 A.

Size as shipped, screenings. Size as used, over 1 inch, 21.2 per cent; ½ inch to 1 inch, 23.6 per cent; ¼ inch to ½ inch, 18.2 per cent; under ¼ inch, 37.0 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 138, Illinois No. 11 A.

Size as shipped, screenings. Size as used, over 1 inch, 17.4 per cent; ½ inch to 1 inch, 21.9 per cent; ¼ inch to ½ inch, 15.6 per cent; under ¼ inch, 45.1 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 139, Illinois No. 11 A.

Size as shipped, screenings. Size as used, over 1 inch, 17.3 per cent; ½ inch to 1 inch, 19.1 per cent; ¼ inch to ½ inch, 15.8 per cent; under ¼ inch, 47.8 per cent. Duration of test, 9.93 hours. Kind of grate, rocking.

Test 141, Illinois No. 11 A.

Size as shipped, screenings. Size as used, over 1 inch, 20.4 per cent; ½ inch to 1 inch, 25.3 per cent; ¼ inch to ½ inch, 18.5 per cent; under ¼ inch, 35.8 per cent. Duration of test, 7.08 hours. Kind of grate, plain.

Test 111, Illinois No. 11 B.

Size as shipped, run of mine. Size as used, over 1 inch, 39.4 per cent; ½ inch to 1 inch, 25.2 per cent; ¼ inch to ½ inch, 14.5 per cent; under ¼ inch, 20.9 per cent. Duration of test, 10.08 hours. Kind of grate, rocking.

Test 112, Illinois No. 11 B.

Size as shipped, run of mine. Size as used, over 1 inch, 28.9 per cent; ½ inch to 1 inch, 21.3 per cent; ¼ inch to ½ inch, 17.8 per cent; under ¼ inch, 32.0 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

Test 115, Illinois No. 11 B.

Size as shipped, run of mine. Size as used, over 1 inch, 24.6 per cent; ½ inch to 1 inch, 24.0 per cent; ¼ inch to ½ inch, 18.2 per cent; under ¼ inch, 33.2 per cent. Duration of test, 9.87 hours. Kind of grate, plain.

Test 116, Illinois No. 11 B.

Size as shipped, run of mine. Size as used, over 1 inch, 40.1 per cent; ½ inch to 1 inch, 21.6 per cent; ¼ inch to ½ inch, 15.2 per cent; under ¼ inch, 23.1 per cent. Duration of test, 6.05 hours. Kind of grate, plain.

Test 117, Illinois No. 11 B.

Size as shipped, lump. Size as used, over 1 inch, 33.6 per cent; ½ inch to 1 inch, 24.8 per cent; ¼ inch to ½ inch, 16.3 per cent; under ¼ inch, 25.3 per cent. Duration of test, 10.1 hours. Kind of grate, plain.

Test 118, Illinois No. 11 B.

Size as shipped, lump. Size as used, over 1 inch, 20.4 per cent; ½ inch to 1 inch, 18.2 per cent; ¼ inch to ½ inch, 17.4 per cent; under ¼ inch, 44.0 per cent. Duration of test, 9.9 hours. Kind of grate, plain.

Test 119, Illinois No. 11 B.

Size as shipped, lump. Size as used, over 1 inch, 27.6 per cent; ½ inch to 1 inch, 24.5 per cent; ¼ inch to ½ inch, 18.3 per cent; under ¼ inch, 29.6 per cent. Duration of test, 10.07 hours. Kind of grate, plain.

Test 120, Illinois No. 11 C, washed.

Size as shipped, No. 4 washed. Size as used, over 1 inch, 0 per cent; ½ inch to 1 inch, 16.4 per cent; ¼ inch to ½ inch, 45.8 per cent; under ¼ inch, 37.8 per cent. Washed at mine. Duration of test, 9.95 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 137.	Test 138.	Test 139.	Test 141.	Test 111.	Test 112.
Heating value of coal, B. T. U. per pound dry coal	12,348	12,159	12,254	12,505	12,643	12,775
Force of draft:						
Under stack damper....inch water..	0.60	0.60	0.62	0.60	0.55	0.48
Above fire.....do....	.16	.18	.18	.15	.28	.27
Furnace temperature.....°F..	.....	2376	2435	.....	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	20.98	19.94	19.70	18.81	24.35	22.36
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.17	2.97	3.06	3.11	2.93	2.90
Percentage of rated horsepower of boiler developed..	88.8	83.4	85.8	87.3	82.0	81.2
Water apparently evaporated per pound of coal as fired.....pounds..	6.65	6.59	6.86	6.58	5.23	5.59
Water evaporated from and at 212° F.:						
Per pound of coal as fired...pounds..	7.76	7.68	8.02	7.66	[a] 6.15	[a] 6.59
Per pound of dry coal.....do....	8.42	8.32	8.67	8.29	6.70	7.23
Per pound of combustible.....do....	10.19	10.13	10.42	9.70	8.21	8.99
Efficiency of boiler, including grate, per cent	64.51	66.08	68.33	64.02	51.18	54.65
Coal as fired:						
Per indicated horsepower hour..lbs..	3.64	3.68	3.53	3.69	4.60	4.29
Per electrical horsepower hour...do..	4.50	4.55	4.35	4.56	5.68	5.30
Dry coal:						
Per indicated horsepower hour...do..	3.36	3.40	3.26	3.41	4.22	3.91
Per electrical horsepower hour...do..	4.14	4.20	4.03	4.21	5.21	4.83

	Test 115.	Test 116.	Test 117.	Test 118.	Test 119.	Test 120.
Heating value of coal, B. T. U. per pound dry coal	12,321	12,933	12,537	12,801	13,079	13,370
Force of draft:						
Under stack damper....inch water..	0.61	0.49	0.50	0.39	0.57	0.58
Above fire.....do....	.26	.22	.20	.16	.25	.23
Furnace temperature.....°F..	.....	.....	.....	.....	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	22.89	24.19	23.80	23.16	25.70	25.41
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.42	3.61	3.42	3.32	3.75	3.55
Percentage of rated horsepower of boiler developed	96.0	101.3	95.8	93.1	105.0	99.5
Water apparently evaporated per pound of coal as fired.....pounds..	5.82	5.86	5.73	5.76	5.81	6.03
Water evaporated from and at 212° F.:						
Per pound of coal as fired...pounds..	[a] 6.83	[a] 6.94	[a] 6.71	[a] 6.74	[a] 6.84	[a] 7.08
Per pound of dry coal.....do....	7.49	7.48	7.19	7.19	7.31	7.79
Per pound of combustible.....do....	9.20	8.79	8.51	8.46	8.46	8.74
Efficiency of boiler, including grate, per cent	58.71	55.85	55.38	54.26	53.97	56.27
Coal as fired:						
Per indicated horsepower hour..lbs..	4.14	4.07	4.21	4.19	4.13	3.99
Per electrical horsepower hour...do..	5.11	5.03	5.20	5.18	5.10	4.93
Dry coal:						
Per indicated horsepower hour...do..	3.78	3.78	3.93	3.94	3.87	3.63
Per electrical horsepower hour...do..	4.66	4.67	4.85	4.85	4.78	4.48

[a] A better evaporation would have been obtained if boilers and gas-sampling apparatus had been in better condition, as they were later.

ANALYSES.

	Test 137.	Test 138.	Test 139.	Test 141.	Test 111.	Test 112.
Proximate.						
Moisture	7.84	7.66	7.54	7.65	8.17	8.93
Volatile matter	28.08	29.76	30.09	30.06	31.53	30.73
Fixed carbon	51.54	48.65	49.31	50.50	48.21	48.21
Ash	12.54	13.93	13.06	11.79	12.09	12.13
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	2.35	2.16	2.57	2.09	2.82	2.33
Ultimate.						
Carbon[a]	70.06	69.00	69.44	70.99	70.54	70.22
Hydrogen[a]	4.50	4.43	4.46	4.56	4.57	4.65
Oxygen[a]	7.89	7.76	7.83	8.01	7.20	7.84
Nitrogen[a]	1.39	1.38	1.37	1.41	1.46	1.41
Sulphur[a]	2.55	2.34	2.78	2.26	3.07	2.56
Ash	13.61	15.09	14.12	12.77	13.16	13.32
	100.00	100.00	100.00	100.00	100.00	100.00

	Test 115.	Test 116.	Test 117.	Test 118.	Test 119.	Test 120.
Proximate.						
Moisture	8.85	7.29	6.69	6.16	6.43	9.14
Volatile matter	28.12	31.34	32.95	33.21	32.23	31.03
Fixed carbon	48.08	50.07	47.59	48.91	50.58	52.33
Ash	14.95	11.30	12.77	11.72	10.76	7.50
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	2.24	2.50	3.47	3.14	2.22	1.64
Ultimate.						
Carbon[a]	67.72	71.07	69.56	70.90	71.96	74.65
Hydrogen[a]	4.49	4.70	4.52	4.60	4.77	4.85
Oxygen[a]	7.57	7.92	7.08	7.20	7.95	8.98
Nitrogen[a]	1.36	1.42	1.44	1.46	1.44	1.47
Sulphur	2.46	2.70	3.72	3.35	2.37	1.80
Ash	16.40	12.19	13.68	12.49	11.51	8.25
	100.00	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TESTS.

Test 30, Illinois No. 11 A.

Size as shipped, egg. Size as used, not determined. Duration of test, 53 hours.

Average electrical horsepower	210.0
Average B. T. U. gas, per cubic foot	173.4
Total coal fired ..... pounds..	15,450

Test 36, Illinois No. 11 C.

Size as shipped, No. 5 washed. Size as used, not determined. Duration of test, 54 hours.

Average electrical horsepower	173.9
Average B. T. U. gas, per cubic foot	109.8
Total coal fired ..... pounds..	13,650

Test 42, Illinois No. 11 D.

Size as shipped, No. 3 washed. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	201.0
Average B. T. U. gas, per cubic foot	146.1
Total coal fired ..... pounds..	12,600

Test 48, Illinois No. 11 D.

Size as shipped, No. 3 washed. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	202.5
Average B. T. U. gas, per cubic foot	154.9
Total coal fired ..... pounds..	12,450

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 30.			Test 36.			Test 42.			Test 48.		
	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:												
Available for outside purposes	1.49	1.38	1.22	3.50	3.06	2.65	1.34	1.22	1.12	1.31	1.20	1.11
Developed at switch board	1.39	1.29	1.14	3.27	2.85	2.47	1.25	1.15	1.05	1.23	1.13	1.04
Per brake horsepower:												
Available for outside purposes	1.26	1.18	1.04	2.98	2.60	2.25	1.14	1.04	.96	1.11	1.02	.94
Developed at engine	1.18	1.10	.97	2.78	2.43	2.10	1.07	.97	.90	1.05	.96	.89
Equivalent used by producer plant.												
Per electrical horsepower:												
Available for outside purposes	1.56	1.45	1.28	3.66	3.19	2.77	1.47	1.34	1.24	1.46	1.34	1.24
Developed at switch board	1.46	1.36	1.19	3.42	2.98	2.59	1.38	1.26	1.16	1.37	1.26	1.16
Per brake horsepower:												
Available for outside purposes	1.33	1.23	1.09	3.13	2.72	2.36	1.25	1.14	1.05	1.24	1.14	1.05
Developed at engine	1.24	1.15	1.02	2.91	2.54	2.20	1.17	1.07	.98	1.16	1.07	.99

ANALYSES.

	Test 30.	Test 36.	Test 42.	Test 48.
Coal.				
Moisture	7.08	12.78	8.67	7.99
Volatile matter	32.62	28.03	30.69	32.08
Fixed carbon	49.44	47.63	53.36	52.76
Ash	10.86	11.56	7.28	7.17
	100.00	100.00	100.00	100.00
Sulphur	2.09	1.65	1.53	1.56
Gas by volume.				
Carbon dioxide (CO_2)	6.3	12.2	10.2	7.4
Carbon monoxide (CO)	19.7	12.6	18.3	22.9
Hydrogen (H_2)	9.7	9.5	13.2	13.4
Methane (CH_4)	6.2	3.5	2.6	2.4
Nitrogen (N_2)	58.1	62.1	55.7	53.9
Oxygen (O_2)	.....	.1	.....	.....
	100.0	100.0	100.0	100.0

COKING TEST.

Test 5, Illinois No. 11 D.

Size as shipped, No. 3 washed. Size as used, finely crushed. Duration of test, 48 hours.

Coal charged	pounds	10,000
Coke produced	do	5,400
Breeze produced	do	300
Coke produced	per cent	54.00
Breeze produced	do	3.00
Total percentage yield		57.00

Remarks.—Light-gray and silvery color. Good, strong coke. Might be improved by washing, reducing ash.

ANALYSES.

	Test 5.	
	Coal.	Coke.
Moisture	8.24	1.19
Volatile matter	31.64	.93
Fixed carbon	52.81	85.97
Ash	7.31	11.91
Sulphur	1.55	1.44

ILLINOIS NO. 12.

Bituminous coal from Bush No. 1 mine, Western Coal and Mining Company, Bush, Williamson County, Ill., on the St. Louis, Iron Mountain and Southern Railway.

This sample consisted of run-of-mine coal and was shipped under the supervision of Inspector J. W. Groves. The following tests were made: Washing test No. 106, steaming tests Nos. 127, 128, 131, 133, 136, and steaming test on washed coal No. 135.

Two mine samples were taken from the following places in the mine: No. 1683 from room 10 off the first entry east, on the east side, 1,000 feet northeast of the shaft; No. 1688 from the first north entry, 1,000 feet northwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1683	1688	1762
Air-drying loss		5.20	5.60	3.60
Proximate.	Moisture	8.29	8.41	8.20
	Volatile matter	31.19	34.27	32.26
	Fixed carbon	49.69	45.44	46.59
	Ash	10.83	11.88	12.95
Ultimate.	Sulphur	2.81	3.63	3.48
	Hydrogen			5.09
	Carbon			62.52
	Nitrogen			1.10
	Oxygen			14.86
Calorific value determined:				
	Calories	6,576		6,312
	British thermal units	11,837		11,362

STEAMING TESTS.

Test 127, Illinois No. 12.

Size as shipped, run of mine. Size as used, over 1 inch, 30.8 per cent; ½ inch to 1 inch, 26.5 per cent; ¼ inch to ½ inch, 17.1 per cent; under ¼ inch, 25.6 per cent. Duration of test, 10.03 hours. Kind of grate, plain.

Test 128, Illinois No. 12.

Size as shipped, run of mine. Size as used, over 1 inch, 46.4 per cent; ½ inch to 1 inch, 21.2 per cent; ¼ inch to ½ inch, 12.3 per cent; under ¼ inch, 20.1 per cent. Duration of test, 10.05 hours. Kind of grate, plain.

Test 131, Illinois No. 12.

Size as shipped, run of mine. Size as used, over 1 inch, 23.8 per cent; ½ inch to 1 inch, 18.1 per cent; ¼ inch to ½ inch, 16.6 per cent; under ¼ inch, 41.5 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 133, Illinois No. 12.

Size as shipped, run of mine. Size as used, over 1 inch, 26.4 per cent; ½ inch to 1 inch, 24.3 per cent; ¼ inch to ½ inch, 17.9 per cent; under ¼ inch 31.4 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 135, Illinois No. 12, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 22.5 per cent; ½ inch to 1 inch, 28.6 per cent; ¼ inch to ½ inch, 24.1 per cent; under ¼ inch, 24.8 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 136, Illinois No. 12.

Size as shipped, run of mine. Size as used, over 1 inch, 15.3 per cent; ½ inch to 1 inch, 22.9 per cent; ¼ inch to ½ inch, 20.8 per cent; under ¼ inch, 41 per cent. Duration of test, 9.68 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 127.	Test 128.	Test 131.	Test 133.	Test 135.	Test 136.
Heating value of coal, B. T. U. per pound dry coal	11,963	12,154	11,709	11,849	13,104	11,867
Force of draft:						
Under stack damper....inch water..	0.59	0.46	0.57	0.65	0.63	0.67
Above fire.....do....	.19	.19	.19	.22	.18	.21
Furnace temperature.....°F..	.....	.....	.....	.....	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	21.49	21.45	20.87	22.91	23.09	20.77
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.35	3.51	2.91	3.15	3.62	2.91
Percentage of rated horsepower of boiler developed	94.00	98.3	81.5	88.20	101.3	81.5
Water apparently evaporated per pound of coal, as fired.....pounds..	6.17	6.45	6.06	5.99	6.69	6.00
Water evaporated from and at 212 ° F.:						
Per pound of coal as fired..pounds..	7.15	7.54	7.04	7.00	7.86	7.00
Per pound of dry coal.....do....	7.81	8.19	7.77	7.67	8.75	7.81
Per pound of combustible.....do....	9.60	9.84	10.19	9.73	9.99	9.88
Efficiency of boiler, including grate, per cent	63.04	65.07	64.08	62.51	64.48	63.56
Coal as fired:						
Per indicated horsepower hour, pounds	3.96	3.75	4.02	4.04	3.60	4.04
Per electrical horsepower hour, pounds	4.88	4.63	4.96	4.99	4.44	4.99
Dry coal:						
Per indicated horsepower hour, pounds	3.50	3.45	3.64	3.69	3.23	3.62
Per electrical horsepower hour, pounds	4.50	4.26	4.49	4.55	3.99	4.47

ANALYSES.

	Test 127.	Test 128.	Test 131.	Test 133.	Test 135	Test 136.
Proximate.						
Moisture	8.49	7.93	9.54	8.79	10.19	10.39
Volatile matter	31.04	31.85	29.52	30.70	33.30	29.39
Fixed carbon	45.25	46.18	43.97	44.90	47.27	44.64
Ash	15.22	14.04	16.97	15.61	9.24	15.58
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	3.79	3.92	4.18	4.14	2.58	3.56
Ultimate.						
Carbon[a]	65.71	66.76	63.55	65.00	72.02	65.23
Hydrogen[a]	4.39	4.45	4.24	4.33	4.82	4.36
Oxygen[a]	7.97	8.11	7.71	7.87	8.73	7.91
Nitrogen[a]	1.16	1.17	1.12	1.14	1.27	1.15
Sulphur	4.14	4.26	4.62	4.54	2.87	3.97
Ash	16.63	15.25	18.76	17.12	10.29	17.38
	100.00	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 106, Illinois No. 12.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	18,000
Washed coal	do....	15,900
Refuse	do....	2,100

ANALYSES.

	Test 106.	
	Raw coal.	Washed coal.
Moisture	8.20	13.30
Volatile matter	32.26	.....
Fixed carbon	46.59	.....
Ash	12.95	8.91
Sulphur	3.48	2.48

ILLINOIS NO. 13.

Bituminous coal from Benton mine, Benton Coal Company, Benton, Franklin County, Ill., on the Chicago and Eastern Illinois Railroad.

This sample was shipped as egg coal, which at this mine passes through a 6-inch screen and over a 1½-inch screen. It was loaded under the supervision of Inspector J. W. Groves, and used in making the following tests: Washing test No. 107, coking tests Nos. 2 and 3, steaming tests Nos. 132, 134, and 144, and steaming test on washed coal No. 145; also producer-gas test No. 41.

A sample for chemical analysis was taken on each side of the mine. No. 1695 was cut from the main entry, 80 feet south from the shaft, and No. 1694 was cut in the main entry, 100 feet north of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1695	1694	1786
Air-drying loss		5.30	5.20	4.60
Proximate.	Moisture	10.28	9.46	8.31
	Volatile matter	32.04	33.55	31.65
	Fixed carbon	49.74	48.87	49.56
	Ash	7.94	8.12	10.48
Ultimate.	Sulphur	1.06	1.63	1.55
	Hydrogen	.....	.....	5.18
	Carbon	.....	.....	65.83
	Nitrogen	.....	.....	1.48
	Oxygen	.....	.....	15.48
Calorific value determined:				
Calories		.....	6,661	6,515
British thermal units		.....	11,990	11,727

STEAMING TESTS.

Test 132, Illinois No. 13.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, over 1 inch, 31.0 per cent; ½ inch to 1 inch, 22.6 per cent; ¼ inch to ½ inch, 15.0 per cent; under ¼ inch, 31.4 per cent. Duration of test, 9.98 hours. Kind of grate, rocking.

Test 134, Illinois No. 13.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, over 1 inch, 23.8 per cent; ½ inch to 1 inch, 23.8 per cent; ¼ inch to ½ inch, 20.8 per cent; under ¼ inch, 31.6 per cent. Duration of test, 10.02 hours. Kind of grate, rocking.

Test 144, Illinois No. 13, washed.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, over 1 inch, 30.0 per cent; ½ inch to 1 inch, 27.2 per cent; ¼ inch to ½ inch, 19.0 per cent; under ¼ inch, 23.8 per cent. Duration of test, 8.95 hours. Kind of grate, plain.

Test 145, Illinois No. 13, washed.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, over 1 inch, 25.2 per cent; ½ inch to 1 inch, 18.7 per cent; ¼ inch to ½ inch, 20.1 per cent; under ¼ inch, 36.0 per cent. Duration of test, 7.63 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 132.	Test 134.	Test 144.	Test 145.
Heating value of coal.....B. T. U. per pound dry coal..	12,528	12,667	13,261	13,306
Force of draft:				
Under stack damper.....inch water..	0.48	0.65	0.45	0.46
Above fire.....do....	.13	.18	.10	.13
Furnace temperature.....°F..	.....	.....	.....	.....
Dry coal used per square foot of grate surface per hour, pounds.....	22.06	22.55	20.42	20.14
Equivalent water evaporated per square foot of water-heating surface per hour .....pounds..	3.37	3.39	3.70	3.38
Percentage of rated horsepower of boiler developed.....	94.5	95.0	103.8	94.7
Water apparently evaporated per pound of coal as fired, pounds.....	6.57	6.48	7.05	7.16
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	7.67	7.58	8.20	8.37
Per pound of dry coal.....do....	8.52	8.39	9.08	9.36
Per pound of combustible.....do....	10.16	9.83	10.09	10.36
Efficiency of boiler, including grate.....per cent..	65.67	63.96	66.12	67.93
Coal as fired:				
Per indicated horsepower hour.....pounds..	3.69	3.73	3.45	3.38
Per electrical horsepower hour.....do....	4.55	4.61	4.26	4.17
Dry coal:				
Per indicated horsepower hour.....do....	3.32	3.37	3.12	3.02
Per electrical horsepower hour.....do....	4.10	4.16	3.84	3.73

ANALYSES.

	Test 132.	Test 134.	Test 144.	Test 145.
Proximate.				
Moisture	9.95	9.64	9.67	10.60
Volatile matter	30.22	30.50	32.59	31.38
Fixed carbon	47.73	48.81	50.18	50.84
Ash	12.10	11.05	7.56	7.18
	100.00	100.00	100.00	100.00
Sulphur	1.32	1.59	1.30	1.34
Ultimate.				
Carbon[a]	70.32	71.07	74.52	74.77
Hydrogen[a]	4.55	4.60	4.83	4.84
Oxygen[a]	8.64	8.75	9.17	9.18
Nitrogen[a]	1.58	1.59	1.67	1.68
Sulphur	1.47	1.76	1.44	1.50
Ash	13.44	12.23	8.37	8.03
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 41, Illinois No. 13.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower..... 208.7
Average B. T. U. gas, per cubic foot..... 156.8
Total coal fired.....pounds.. 16,950

	Test 41.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.72	1.57	1.39
Developed at switch board	1.63	1.48	1.32
Per brake horsepower:			
Available for outside purposes	1.46	1.33	1.18
Developed at engine	1.38	1.26	1 12
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.84	1.68	1.49
Developed at switch board	1.74	1.59	1 41
Per brake horsepower:			
Available for outside purposes	1.56	1.42	1.26
Developed at engine	1.48	1.35	1.20

ANALYSES.

	Test 41.		Test 41.
Coal.		*Gas by volume.*	
Moisture	8.72	Carbon dioxide (CO_2)	8.1
Volatile matter	31.07	Carbon monoxide (CO)	21.0
Fixed carbon	49.94	Hydrogen (H_2)	11.6
Ash	10.27	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	56.2
Sulphur	1.66		100.0

WASHING TEST.

Test 107, Illinois No. 13.

Size as shipped, 1½ inch to 6 inch, egg. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	29,950
Washed coal	do....	27,550
Refuse	do....	2,400

ANALYSES.

	Test 107.	
	Raw coal.	Washed coal.
Moisture	8.31	11.15
Volatile matter	31.65	.....
Fixed carbon	49.56	.....
Ash	10.48	7.49
Sulphur	1.55	1.27

COKING TESTS.

Test 2, Illinois No. 13, washed.

Size as shipped, 1½-inch to 6-inch egg. Size as used, finely crushed. Duration of test, 65 hours.

Coal charged	pounds..	10,000
Coke produced	do....	4,600
Breeze produced	do....	718
Coke produced	per cent..	46.00
Breeze produced	do....	7.18
Total percentage yield		53.18

Remarks.—Good hard coke. Washing improves product both in ash and sulphur.

Test 3, Illinois No. 13.

Size as shipped, 1½-inch to 6-inch egg. Size as used, finely crushed. Raw. Duration of test, 65 hours.

Coal charged	pounds..	12,000
Coke produced	do....	5,358
Breeze produced	do....	1,327
Coke produced	per cent..	44.65
Breeze produced	do....	11.06
Total percentage yield		55.71

Remarks.—Coke has dull appearance. Softer than coke from washed coal. Seasoned ovens would probably give better results.

ANALYSES.

	Test 2.		Test 3.	
	Coal.	Coke.	Coal.	Coke.
Moisture	11.44	4.60	10.56	2.73
Volatile matter	30.95	1.68	30.08	1.36
Fixed carbon	50.16	82.08	49.08	79.30
Ash	7.45	11.64	10.28	16.61
Sulphur	1.25	1.27	1.71	1.77

ILLINOIS NO. 14.[a]

Bituminous coal from No. 2 mine, Capital Coal Company, east side of Springfield, Sangamon County, Ill., on the Illinois Central Railroad.

This sample was shipped under the supervision of Inspector J. W. Groves and consisted of lump coal. In making lump coal at this mine it is passed over a 1½-inch bar screen. The following tests were made on this coal: Washing test No. 105, steaming tests Nos. 123 and 125, and steaming test on washed coal No. 130; also producer-gas test No. 37.

Two mine samples were cut from widely separated points in the mine. No. 1704 was taken from the face of room 30 off the twenty-first south entry, 1 mile southeast of the shaft; No. 1705 was taken in the sixteenth entry off the fourth "stub" entry, 4,000 feet northeast of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1704	1705	1740
Air-drying loss		10.80	11.20	8.00
Proximate.	Moisture	13.89	14.45	12.77
	Volatile matter	33.96	34.79	34.68
	Fixed carbon	40.89	40.10	40.77
	Ash	11.26	10.66	11.78
Ultimate.	Sulphur	3.83	3.46	4.16
	Hydrogen	.....	.....	5.49
	Carbon	.....	.....	58.74
	Nitrogen	.....	.....	1.09
	Oxygen	.....	.....	18.74
Calorific value determined:				
	Calories	5,909	.....	5,976
	British thermal units	10,636	.....	10,757

[a] This sample was furnished by the Illinois Central Railroad.

STEAMING TESTS.

Test 123, Illinois No. 14.

Size as shipped, lump. Size as used, over 1 inch, 23.3 per cent; ½ inch to 1 inch, 27.9 per cent; ¼ inch to ½ inch, 19.6 per cent; under ¼ inch, 29.2 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 125, Illinois No. 14.

Size as shipped, lump. Size as used, over 1 inch, 30.4 per cent; ½ inch to 1 inch, 25.2 per cent; ¼ inch to ½ inch, 17.7 per cent; under ¼ inch, 26.7 per cent. Duration of test, 9.87 hours. Kind of grate, plain.

Test 130, Illinois No. 14, washed

Size as shipped, lump. Size as used, over 1 inch, 21.4 per cent; ½ inch to 1 inch, 27.7 per cent; ¼ inch to ½ inch, 25 per cent; under ¼ inch, 25.9 per cent. Duration of test, 9.92 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 123.	Test 125.	Test 130.
Heating value of coal.....B. T. U. per pound dry coal..	12,008	12,125	12,731
Force of draft:			
Under stack damper.....inch water..	0.60	0.57	0.52
Above fire.....do....	.28	.20	.14
Furnace temperature.....°F..	.....	.....	.....
Dry coal used per square foot of grate surface per hour.....pounds..	23.60	20.30	21.63
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.10	3.08	3.33
Percentage of rated horsepower of boiler developed.....	87.0	86.2	93.3
Water apparently evaporated per pound of coal as fired.....pounds..	5.57	5.70	5.57
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	6.49	6.62	6.49
Per pound of dry coal.....do....	7.34	7.58	7.71
Per pound of combustible.....do....	8.99	9.05	8.86
Efficiency of boiler, including grate.....per cent..	59.03	60.37	58.48
Coal as fired:			
Per indicated horsepower hour.....pounds..	4.36	4.27	4.36
Per electrical horsepower hour .....do....	5.38	5.27	5.38
Dry coal:			
Per indicated horsepower hour.....do....	3.85	3.73	3.67
Per electrical horsepower hour.....do....	4.76	4.61	4.53

ANALYSES.

	Test 123.	Test 125.	Test 130.		Test 123.	Test 125.	Test 130.
Proximate.				*Ultimate.*			
Moisture	11.65	12.61	15.83	Carbon [a]	65.44	66.72	70.11
Volatile matter	34.67	33.60	33.50	Hydrogen [a]	4.53	4.02	4.86
Fixed carbon	40.12	41.30	41.38	Oxygen [a]	8.24	8.38	8.83
Ash	13.56	12.49	9.29	Nitrogen [a]	1.22	1.25	1.31
	100.00	100.00	100.00	Sulphur	5.23	4.74	3.85
Sulphur	4.62	4.13	3.24	Ash	15.34	14.29	11.04
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 37, Illinois No. 14.

Size as shipped, lump. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	199.0
Average B. T. U. gas, per cubic foot	150.6
Total coal fired, pounds	16,650

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 37.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.78	1.55	1.33
Developed at switch board	1.67	1.46	1.25
Per brake horsepower:			
Available for outside purposes	1.51	1.32	1.13
Developed at engine	1.42	1.24	1.07
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.90	1.66	1.42
Developed at switch board	1.79	1.56	1.34
Per brake horsepower:			
Available for outside purposes	1.61	1.41	1.21
Developed at engine	1.52	1.33	1.14

ANALYSES.

	Test 37.		Test 37.
Coal.		*Gas by volume.*	
Moisture	12.68	Carbon dioxide (CO_2)	8.2
Volatile matter	33.36	Carbon monoxide (CO)	21.0
Fixed carbon	41.57	Hydrogen (H_2)	10.7
Ash	12.39	Methane (CH_4)	3.2
	100.00	Nitrogen (N_2)	56.9
Sulphur	4.16		100.0

WASHING TEST.

Test 105, Illinois No. 14.

Size as shipped, lump. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	18,000
Washed coal	do....	15,955
Refuse	do....	2,045

ANALYSES.

	Test 105.	
	Raw coal.	Washed coal.
Moisture	12.77	16.32
Volatile matter	34.68	.....
Fixed carbon	40.77	.....
Ash	11.78	9.37
Sulphur	4.16	3.29

ILLINOIS NO. 15.[a]

Bituminous coal from south mine of Pettinger & Davis, Centralia, Marion County, Ill., on the Illinois Central Railroad.

This sample was shipped as lump coal (over 6-inch screen), but it was necessary to close one-half of the screen while the car was being loaded, and consequently a large amount of the smaller sizes of coal, which should have gone through the screen, passed into the car. The sample was inspected by Inspector J. S. Burrows and was used in making the following tests: Washing test No. 110, steaming test No. 126, steaming test on washed coal No. 152, and producer-gas test No. 40.

One of the mine samples taken in this mine (No. 1725) came from the sixteenth east entry, 3,000 feet southeast of the shaft, and the other (No. 1726) was cut from the fourteenth south entry, 4,500 feet southwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1725	1726	1761
Air-drying loss		7.20	7.80	4.20
Proximate.	Moisture	10.25	11.88	9.95
	Volatile matter	37.43	35.84	34.76
	Fixed carbon	39.79	43.45	42.06
	Ash	12.53	8.83	13.23
Ultimate.	Sulphur	3.70	3.25	3.87
	Hydrogen	.....	.....	5.25
	Carbon	.....	.....	59.64
	Nitrogen	.....	.....	1.04
	Oxygen	.....	.....	16.97
Calorific value determined:				
	Calories	6,154	.....	6,089
	British thermal units	11,077	.....	10,960

[a] Sample furnished by the Illinois Central Railroad.

STEAMING TESTS.

Test 126, Illinois No. 15.

Size as shipped, lump and egg. Size as used, over 1 inch, 20.5 per cent; ½ inch to 1 inch, 25.9 per cent; ¼ inch to ½ inch, 21.1 per cent; under ¼ inch, 32.5 per cent. Duration of test, 9.88 hours. Kind of grate, plain.

Test 152, Illinois No. 15, washed.

Size as shipped, lump and egg. Size as used, over 1 inch, 25.5 per cent; ½ inch to 1 inch, 31.3 per cent; ¼ inch to ½ inch, 21.8 per cent; under ¼ inch, 21.4 per cent. Duration of test, 10.03 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 126.	Test 152.
Heating value of coal.....B. T. U. per pound dry coal..	11,749	13,104
Force of draft:		
Under stack damper.....inch water..	0.55	0.46
Above fire.....do....	.18	.13
Furnace temperature.....°F..	.....	2,439
Dry coal used per square foot of grate surface, per hour.....pounds..	20.44	19.63
Equivalent water evaporated per square foot of water-heating surface, per hour.....pounds..	3.11	3.36
Percentage of rated horsepower of boiler developed.....	87.2	94.3
Water apparently evaporated per pound of coal as fired.....pounds..	5.94	6.51
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	6.86	7.57
Per pound of dry coal.....do....	7.62	8.59
Per pound of combustible.....do....	9.49	9.64
Efficiency of boiler, including grate.....per cent..	62.63	63.30
Coal as fired:		
Per indicated horsepower hour.....pounds..	4.12	3.74
Per electrical horsepower hour.....do....	5.09	4.61
Dry coal:		
Per indicated horsepower hour.....do....	3.71	3.29
Per electrical horsepower hour.....do....	4.58	4.06

ANALYSES.

	Test 126.	Test 152.		Test 126.	Test 152.
Proximate.			*Ultimate.*		
Moisture	10.00	11.81	Carbon[a]	63.78	71.17
Volatile matter	33.39	37.09	Hydrogen[a]	4.43	4.94
Fixed carbon	41.20	42.69	Oxygen[a]	8.70	9.71
Ash	15.41	8.41	Nitrogen[a]	1.12	1.24
	100.00	100.00	Sulphur	4.85	3.40
Sulphur	4.36	3.00	Ash	17.12	9.54
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 40, Illinois No. 15.

Size as shipped, lump and egg. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	200.5
Average B. T. U. gas, per cubic foot	142.9
Total coal fired, pounds	16,950

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 40.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.80	1.63	1.39
Developed at switch board	1.69	1.53	1.30
Per brake horsepower:			
Available for outside purposes	1.53	1.39	1.18
Developed at engine	1.44	1.30	1.11
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.91	1.73	1.45
Developed at switch board	1.80	1.63	1.36
Per brake horsepower:			
Available for outside purposes	1.63	1.47	1.23
Developed at engine	1.53	1.38	1.16

ANALYSES.

	Test 40.		Test 40.
Coal.		*Gas by volume.*	
Moisture	9.44	Carbon dioxide (CO_2)	11.1
Volatile matter	35.48	Carbon monoxide (CO)	16.1
Fixed carbon	41.53	Hydrogen (H_2)	11.2
Ash	13.55	Methane (CH_4)	3.3
	100.00	Nitrogen (N_2)	58.3
Sulphur	4.06		100.0

WASHING TEST.

Test 110, Illinois No. 15.

Size as shipped, lump and egg. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	18,000
Washed coal	do....	13,035
Refuse	do....	4,965

ANALYSES.

	Test 110.	
	Raw coal.	Washed coal.
Moisture	9.95	11.81
Volatile matter	34.76	.....
Fixed carbon	42.06	.....
Ash	13.23	8.41
Sulphur	3.87	3.00

ILLINOIS NO. 16.[a]

Bituminous coal from mine No. 7, Big Muddy Coal and Iron Company, Herrin, Williamson County, Ill., on the Illinois Central Railroad.

Lump and egg coal were shipped for testing under the supervision of Inspector J. S. Burrows. This mixture is made by passing the run-of-mine coal over a screen with a 3-inch mesh. The coal was used in making washing test No. 111, coking tests Nos. 7 and 10, steaming test No. 150, and producer-gas test No. 43.

Two mine samples were taken for chemical analyses at working faces in the mine, as follows: No. 1731 in room 17 off the sixth south entry on the west side, 2,300 feet southwest of the shaft; No. 1732 in room 14 off the fifth north entry on the east side, 2,400 feet northeast of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car samples.
Laboratory number		1731	1732	1820
Air-drying loss		5.70	4.80	4.00
Proximate.	Moisture	9.37	8.59	8.43
	Volatile matter	30.69	31.07	30.08
	Fixed carbon	52.57	53.37	51.89
	Ash	7.37	6.97	9.60
Ultimate.	Sulphur	1.25	1.78	1.14
	Hydrogen	.....	.....	5.18
	Carbon	.....	.....	67.33
	Nitrogen	.....	.....	1.50
	Oxygen	.....	.....	15.25
Calorific value determined:				
	Calories	6,699	.....	6,644
	British thermal units	12,058	.....	11,959

[a] Furnished by the Illinois Central Railroad Company.

STEAMING TEST.

Test 150, Illinois No. 16.

Size as shipped, lump and egg. Size as used, over 1 inch, 48.1 per cent; ½ inch to 1 inch, 21.0 per cent; ¼ inch to ½ inch, 12.3 per cent; under ¼ inch, 18.6 per cent. Duration of test, 7.53 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 150.
Heating value of coal.....B. T. U. per pound dry coal..	12,874
Force of draft:	
Under stack damper.....inch water..	0.46
Above fire.....do....	.11
Furnace temperature.....°F..	.....
Dry coal used per square foot of grate surface per hour.....pounds..	19.63
Equivalent water evaporated per square foot of water-heating surface per hour.....do....	3.56
Percentage of rated horsepower of boiler developed.....	99.8
Water apparently evaporated per pound of coal as fired.....pounds..	7.11
Water evaporated from and at 212° F.:	
Per pound of coal as fired.....do....	8.24
Per pound of dry coal.....do....	9.08
Per pound of combustible.....do....	10.42
Efficiency of boiler, including grate.....per cent..	68.11
Coal as fired:	
Per indicated horsepower hour.....pounds..	3.43
Per electrical horsepower hour.....do....	4.24
Dry coal:	
Per indicated horsepower hour.....do....	3.11
Per electrical horsepower hour.....do....	3.85

ANALYSES.

	Test 150.		Test 150.
Proximate.		*Ultimate.*	
Moisture	9.16	Carbon[a]	72.31
Volatile matter	29.57	Hydrogen[a]	4.56
Fixed carbon	51.04	Oxygen[a]	8.33
Ash	10.23	Nitrogen[a]	1.60
		Sulphur	1.94
	100.00	Ash	11.26
Sulphur	1.76		
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 43, Illinois No. 16.

Size as shipped, lump and egg. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	201.1
Average B. T. U. gas, per cubic foot	149.5
Total coal fired.....pounds..	17,250

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 43.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.81	1.67	1.48
Developed at switch board	1.72	1.58	1.41
Per brake horsepower:			
Available for outside purposes	1.54	1.42	1.26
Developed at engine	1.40	1.35	1.19
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.91	1.77	1.57
Developed at switch board	1.81	1.67	1.48
Per brake horsepower:			
Available for outside purposes	1.62	1.50	1.33
Developed at engine	1.54	1.42	1.26

ANALYSES.

	Test 43.		Test 43.
Coal.		*Gas by volume.*	
Moisture	7.68	Carbon dioxide (CO_2)	8.0
Volatile matter	30.62	Carbon monoxide (CO)	21.6
Fixed carbon	51.33	Hydrogen (H_2)	12.9
Ash	10.37	Methane (CH_4)	2.7
	100.00	Nitrogen (N_2)	54.8
Sulphur	1.47		100.0

WASHING TEST.

Test 111, Illinois No. 16.

Size as shipped, lump and egg. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	14,000
Washed coal	do	12,500
Refuse	do	1,500

ANALYSES.

	Test 111.	
	Raw coal.	Washed coal.
Moisture	8.43	10.14
Volatile matter	30.08	.....
Fixed carbon	51.89	.....
Ash	9.60	8.06
Sulphur	1.14	1.02

COKING TESTS.

Test 7, Illinois No. 16.

Size as shipped, lump and egg. Size as used, finely crushed. Raw. Duration of test,—hours.

Remarks.—Accident to charging larry necessitated discontinuing test. Coal burned to keep oven hot.

Test 10, Illinois No. 16, washed.

Size as shipped, lump and egg. Size as used, finely crushed. Duration of test, 66 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,579
Breeze produced	do....	910
Coke produced	per cent..	55.79
Breeze produced	do....	9.10
Total percentage yield		64.89

Remarks.—Dull-gray color. Poor coke physically.

ANALYSES.

	Test 10.	
	Coal.	Coke.
Moisture	9.79	2.14
Volatile matter	30.35	1.46
Fixed carbon	51.79	83.96
Ash	8.07	12.44
Sulphur	1.09	1.02

ILLINOIS NO. 18.[a]

Bituminous coal from La Salle shaft mine, La Salle County Carbon Coal Company, La Salle, La Salle County, Ill., on the Illinois Central Railroad.

The sample shipped for testing consisted of lump coal passed over a 6-inch mesh screen. It was loaded under the supervision of Inspector J. S. Burrows, and used for the following tests: Washing test No. 109, steaming tests Nos. 140 and 148, steaming tests on washed coal Nos. 147 and 149, and producer-gas test No. 45.

Two mine samples were taken for chemical analysis, as follows: No. 1741 was cut in the twelfth west entry off the north entry; No. 1742 was cut in the third east entry off the third south entry, 4,000 feet from the shaft and 8,000 feet from No. 1741.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1741	1742	1779
Air-drying loss		11.00	11.20	8.40
Proximate.	Moisture	13.87	15.55	12.39
	Volatile matter	37.26	36.21	36.89
	Fixed carbon	38.56	40.66	41.80
	Ash	10.31	7.58	8.92
Ultimate.	Sulphur	3.44	3.01	3.92
	Hydrogen	.....	.....	5.85
	Carbon	.....	.....	61.29
	Nitrogen	.....	.....	1.00
	Oxygen	.....	.....	19.02
Calorific value determined:				
	Calories	6,103	.....	6,333
	British thermal units	10,985	.....	11,399

[a] Sample furnished by Illinois Central Railroad.

STEAMING TESTS.

Test 140, Illinois No. 18.

Size as shipped, lump. Size as used, over 1 inch, 37.3 per cent; ½ inch to 1 inch, 22.2 per cent; ¼ inch to ½ inch, 15.9 per cent; under ¼ inch, 24.6 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 147, Illinois No. 18, washed.

Size as shipped, lump. Size as used, over 1 inch, 9.5 per cent; ½ inch to 1 inch, 25.5 per cent; ¼ inch to ½ inch, 29.6 per cent; under ¼ inch, 35.4 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 148, Illinois No. 18.

Size as shipped, lump. Size as used, over 1 inch, 27.1 per cent; ½ inch to 1 inch, 25.7 per cent; ¼ inch to ½ inch, 17.9 per cent; under ¼ inch, 29.3 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 149, Illinois No. 18, washed.

Size as shipped, lump. Size as used, over 1 inch, 21.7 per cent; ½ inch to 1 inch, 22.7 per cent; ¼ inch to ½ inch, 28.8 per cent; under ¼ inch, 26.8 per cent. Duration of test, 5.32 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 140.	Test 147.	Test 148.	Test 149.
Heating value of coal.....B. T. U. per pound dry coal..	12,951	13,554	12,991	13,432
Force of draft:				
Under stack damper.....inch water..	0.63	0.57	0.53	0.56
Above fire.....do....	.18	.17	.19	.14
Furnace temperature.....°F..	.....	.....	.....	2060
Dry coal used per square foot of grate surface per hour, pounds.....	18.51	19.53	18.86	17.83
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.86	3.12	2.99	3.29
Percentage of rated horsepower of boiler developed.....	80.1	87.4	83.9	92.2
Water apparently evaporated per pound of coal as fired, pounds.....	6.51	6.49	6.13	6.61
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	7.60	7.57	7.06	7.70
Per pound of dry coal.....do....	8.61	8.91	7.94	9.23
Per pound of combustible.....do....	9.90	9.86	9.13	10.08
Efficiency of boiler, including grate.....per cent..	64.20	63.48	59.02	66.36
Coal as fired:				
Per indicated horsepower hour.....pounds..	3.72	3.74	4.01	3.67
Per electrical horsepower hour.....do....	4.59	4.61	4.95	4.53
Dry coal:				
Per indicated horsepower hour.....do....	3.28	3.17	3.56	3.06
Per electrical horsepower hour.....do....	4.06	3.92	4.40	3.78

ANALYSES.

	Test 140.	Test 147.	Test 148.	Test 149.
Proximate.				
Moisture.....	11.72	14.99	11.10	16.64
Volatile matter.....	37.27	37.24	37.11	36.13
Fixed carbon.....	41.73	42.00	42.14	41.51
Ash.....	9.28	5.77	9.65	5.72
	100.00	100.00	100.00	100.00
Sulphur.....	4.07	2.98	3.37	2.72

ANALYSES—continued.

	Test 140.	Test 147.	Test 148.	Test 149.
Ultimate.				
Carbon[a]	69.57	73.53	69.97	73.68
Hydrogen[a]	5.09	5.36	5.11	5.37
Oxygen[a]	9.09	9.61	9.14	9.63
Nitrogen[a]	1.13	1.20	1.14	1.20
Sulphur	4.61	3.51	3.79	3.26
Ash	10.51	6.79	10.85	6.86
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 45, Illinois No. 18.

Size as shipped, lump. Size as used, not determined. Duration of test, 5½ hours.

Average electrical horsepower		201.7
Average B. T. U. gas, per cubic foot		147.7
Total coal fired	pounds..	16,200

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 45.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.71	1.49	1.31
Developed at switch board	1.61	1.40	1.23
Per brake horsepower:			
Available for outside purposes	1.45	1.26	1.12
Developed at engine	1.37	1.19	1.05
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.85	1.61	1.42
Developed at switch board	1.74	1.51	1.33
Per brake horsepower:			
Available for outside purposes	1.57	1.36	1.21
Developed at engine	1.48	1.28	1.13

ANALYSES.

	Test 45.		Test 45.
Coal.		*Gas by volume.*	
Moisture	13.19	Carbon dioxide (CO_2)	11.4
Volatile matter	35.93	Carbon monoxide (CO)	17.2
Fixed carbon	40.84	Hydrogen (H_2)	12.8
Ash	10.04	Methane (CH_4)	3.2
	100.00	Nitrogen (N_2)	55.4
Sulphur	4.59		100.0

WASHING TEST.

Test 109, Illinois No. 18.

Size as shipped, lump. Size as used, crushed to 2 inches. Jig used, Stewart modified

Raw coal	pounds..	18,000
Washed coal	do...	14,400
Refuse	do...	3,600

ANALYSES.

	Test 109.	
	Raw coal.	Washed coal.
Moisture	12.39	14.99
Volatile matter	36.89	.....
Fixed carbon	41.80	.....
Ash	8.92	5.77
Sulphur	3.92	2.98

ILLINOIS NO. 19.

Bituminous coal from Zeigler mine, Zeigler Coal Company, Zeigler, Franklin County, Ill., on the Illinois Central Railroad.

Two samples were loaded under the supervision of Inspector J. W. Groves as follows: Illinois No. 19 A was shipped as "three-fourths inch coal," which had passed over a three-fourths inch perforated shaking screen. It was used in making coking tests Nos. 11 and 15 and steaming tests Nos. 160, 161, 163, 170, and 171. Illinois No. 19 B was shipped as "3-inch coal" which had passed over a 1½-inch perforated shaking screen. It was used in making steaming tests Nos. 175, 204, and 205, producer-gas test No. 55, and coking test No. 19.

Two mine samples were collected from this mine for chemical analysis. No. 1871 was cut from the face of room 5, off the first west entry on the north side, 600 feet northwest of the shaft. No. 1872 was cut from room 5, off the third west entry on the south side, 1,050 feet southwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car samples.	
Laboratory number		1871	1872	1926	2020
Air-drying loss		5.20	5.60	9.10	5.60
Proximate.	Moisture	9.90	10.53	14.91	10.72
	Volatile matter	28.67	29.06	26.66	29.86
	Fixed carbon	53.69	53.01	49.50	50.06
	Ash	7.74	7.40	8.93	9.36
Ultimate.	Sulphur	.48	.47	.52	.91
	Hydrogen	.....	.....	5.42	5.30
	Carbon	.....	.....	62.76	66.74
	Nitrogen	.....	.....	1.35	1.40
	Oxygen	.....	.....	21.02	16.29
Calorific value determined:					
Calories		6,667	.....	6,088	6,492
British thermal units		12,001	.....	10,958	11,686

STEAMING TESTS.

Test 160, Illinois No. 19 A.

Size as shipped, ¾-inch coal. Size as used, ½ inch to 1 inch, 21.3 per cent; ¼ inch to ½ inch, 32.0 per cent; under ¼ inch, 46.7 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 161, Illinois No. 19 A.

Size as shipped, ¾-inch coal. Size as used, over 1 inch, 0 per cent; ½ inch to 1 inch, 13.6 per cent; ¼ inch to ½ inch, 27.2 per cent; under ¼ inch, 59.2 per cent. Duration of test, 9.97 hours. Kind of grate, plain.

Test 163, Illinois No. 19 A.

Size as shipped, ¾-inch coal. Size as used, over 1 inch, 0 per cent; ½ inch to 1 inch, 17.7 per cent; ¼ inch to ½ inch, 34.7 per cent; under ¼ inch, 47.6 per cent. Duration of test, 9.98 hours. Kind of grate, plain.

Test 170, Illinois No. 19 A.

Size as shipped, ¾-inch coal. Size as used, over 1 inch, 0 per cent; ½ inch to 1 inch, 13.6 per cent; ¼ inch to ½ inch, 31.3 per cent; under ¼ inch, 55.1 per cent. Duration of test, 9.07 hours. Kind of grate, rocking.

Test 171, Illinois No. 19 A.

Size as shipped, ¾-inch coal. Size as used, over 1 inch, 0 per cent; ½ inch to 1 inch, 13.6 per cent; ¼ inch to ½ inch, 31.8 per cent; under ¼ inch, 54.6 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

Test 175, Illinois No. 19 B.

Size as shipped, 3-inch coal. Size as used, over 1 inch, 60.2 per cent; ½ inch to 1 inch, 15.7 per cent; ¼ inch to ½ inch, 9.2 per cent; under ¼ inch, 14.9 per cent. Duration of test, 9.9 hours. Kind of grate, plain.

Test 204, Illinois No. 19 B.

Size as shipped, 3-inch coal. Size as used, over 1 inch, 44.0 per cent; ½ inch to 1 inch, 17.2 per cent; ¼ inch to ½ inch, 12.3 per cent; under ¼ inch, 26.5 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 205, Illinois No. 19 B.

Size as shipped, 3-inch coal. Size as used, over 1 inch, 54.4 per cent; ½ inch to 1 inch, 15.1 per cent; ¼ inch to ½ inch, 10.7 per cent; under ¼ inch, 19.8 per cent. Duration of test, 9.93 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 160.	Test 161.	Test 163.	Test 170.	Test 171.	Test 175.	Test 204.	Test 205.
Heating value of coal, B. T. U. per pound dry coal	13,036	12,911	13,068	12,857	12,917	13,005	13,050	13,001
Force of draft:								
Under stack damper, inch water	0.40	0.54	0.67	0.56	0.49	0.41	0.41	0.40
Above fire ....inch water	.14	.20	.17	.16	.17	.09	.11	.12
Furnace temperature....°F	2,428	2,080	2,227	2,039	.....	2,470	2,447	2,448
Dry coal used per square foot of grate surface per hour...pounds	18.47	17.77	20.79	20.22	20.08	20.54	20.69	20.38
Equivalent water evaporated per square foot of water-heating surface per hour ....pounds	3.07	3.12	3.57	3.10	3.23	3.73	3.50	3.38
Percentage of rated horsepower of boiler developed	86.1	87.6	100.2	87.0	90.6	104.7	98.2	94.9
Water apparently evaporated per pound of coal as fired....pounds	6.27	6.54	6.45	6.37	6.71	6.96	7.27	7.11
Water evaporated from and at 212 °F.:								
Per pound of coal as fired, pounds	7.27	7.62	7.50	7.42	7.79	8.13	8.54	8.32
Per pound of dry coal..pounds	8.33	8.80	8.61	8.56	8.97	9.10	9.45	9.27
Per pound of combustible..do	9.45	10.17	9.70	9.85	10.30	10.53	10.83	10.83
Efficiency of boiler, including grate, per cent	61.71	65.82	63.63	64.29	67.06	67.50	69.93	68.86
Coal as fired:								
Per indicated horsepower hour, pounds	3.89	3.71	3.77	3.81	3.63	3.48	3.31	3.40
Per electrical horsepower hour, pounds	4.80	4.58	4.66	4.71	4.48	4.30	4.09	4.20
Dry coal:								
Per indicated horsepower hour, pounds	3.40	3.21	3.28	3.30	3.15	3.11	2.99	3.05
Per electrical horsepower hour, pounds	4.19	3.97	4.06	4.08	3.89	3.84	3.70	3.77

ANALYSES.

	Test 160.	Test 161.	Test 163.	Test 170.	Test 171.	Test 175.	Test 204.	Test 205.
Proximate.								
Moisture	12.79	13.43	12.86	13.28	13.19	10.72	9.56	10.30
Volatile matter	27.24	27.60	28.30	27.72	27.56	29.77	29.40	29.20
Fixed carbon	51.73	50.08	50.80	49.75	50.33	49.30	51.11	50.27
Ash	8.24	8.89	8.04	9.25	8.92	10.21	9.93	10.23
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	.49	.50	.51	.50	.50	.47	.61	.55
Ultimate.								
Carbon[a]	74.67	73.99	74.83	73.65	73.97	74.37	74.62	74.33
Hydrogen[a]	4.47	4.44	4.49	4.42	4.44	4.59	4.60	4.58
Oxygen[a]	9.24	9.16	9.25	9.10	9.14	7.52	7.56	7.51
Nitrogen[a]	1.61	1.58	1.61	1.58	1.59	1.56	1.57	1.56
Sulphur	.56	.58	.59	.58	.58	.53	.67	.61
Ash	9.45	10.25	9.23	10.67	10.28	11.43	10.98	11.41
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 55, Illinois No. 19 B.

Size as shipped, lump, 3 inch. Size as used, over 1 inch, 77 per cent; ½ inch to 1 inch, 9 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 9 per cent. Duration of test, 50 hours.

Average electrical horsepower 201.1
Average B. T. U. gas, per cubic foot 164.1
Total coal fired ..... pounds.. 13,950

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 55.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.47	1.33	1.19
Developed at switch board	1.39	1.26	1.12
Per brake horsepower:			
Available for outside purposes	1.25	1.13	1.01
Developed at engine	1.18	1.07	.95
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.55	1.40	1.26
Developed at switch board	1.47	1.33	1.19
Per brake horsepower:			
Available for outside purposes	1.32	1.19	1.07
Developed at engine	1.25	1.13	1.01

ANALYSES.

	Test 55.		Test 55.
Coal.		*Gas by volume.*	
Moisture	9.64	Carbon dioxide (CO_2)	7.4
Volatile matter	30.68	Carbon monoxide (CO)	23.9
Fixed carbon	50.22	Hydrogen (H_2)	15.7
Ash	9.46	Methane (CH_4)	2.1
	100.00	Nitrogen (N_2)	50.9
Sulphur	.53		100.00

COKING TESTS.

Test 11, Illinois No. 19 A.

Size as shipped, ¾ inch. Size as used, finely crushed. Raw. Duration of test, 48 hours. Coal charged, 10,000 pounds.

Remarks.—No coke produced.

Test 15, Illinois No. 19 A.

Size as shipped, ¾ inch. Size as used, finely crushed. Raw. Duration of test, 24 hours. Coal charged, 6,000 pounds.

Remarks.—No coke produced.

Test 19, Illinois No. 19 B.

Size as shipped, 3 inches. Size as used, finely crushed. Raw. Duration of test, 47 hours. Coal charged, 6,000 pounds.

Remarks.—No coke produced from this coal. Three trials.

INDIANA NO. 8.

Bituminous coal from mine No. 3, J. Woolley Coal Company, near Boonville, Warrick County, Ind., on the Southern Railway.

This sample, which was shipped under the supervision of Inspector J. W. Groves, consisted of nut and slack coal mixed. It was used in making washing test No. 115, coking test No. 14, steaming test No. 162, and producer-gas test No. 53.

Two mine samples were sent to the laboratory for chemical analysis; they were taken from the mine as follows: No. 1759 was taken from a point 1,500 feet northeast of the shaft; No. 1760 was taken from the face of a room 600 feet northwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1759	1760	1941
Air-drying loss		7.60	7.00	8.50
Proximate.	Moisture	11.28	11.10	13.18
	Volatile matter	38.04	37.04	31.92
	Fixed carbon	43.05	42.18	39.27
	Ash	7.63	9.68	15.63
Ultimate.	Sulphur	3.58	4.33	4.79
	Hydrogen	.....	.....	5.36
	Carbon	.....	.....	54.52
	Nitrogen	.....	.....	1.08
	Oxygen	.....	.....	18.62
Calorific value determined:				
	Calories	6,551	.....	5,572
	British thermal units	11,792	.....	10,030

STEAMING TEST.

Test 162, Indiana No. 3.

Size as shipped, nut and slack. Size as used, over 1 inch, 28.4 per cent; ½ inch to 1 inch, 25.8 per cent; ¼ inch to ½ inch, 16.4 per cent; under ¼ inch, 29.4 per cent. Duration of test, 9.65 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 162.
Heating value of coal.....B. T. U. per pound dry coal..	11,669
Force of draft:	
Under stack damper.....inch water..	0.51
Above fire.....do....	.15
Furnace temperature.....°F..	23.51
Dry coal used per square foot of grate surface per hour.....pounds..	20.05
Equivalent water evaporated per square foot of water-heating surface per hour.....do....	3.25
Percentage of rated horsepower of boiler developed.....	91.1
Water apparently evaporated per pound of coal as fired.....pounds..	6.14
Water evaporated from and at 212° F.:	
Per pound of coal as fired.....do....	7.10
Per pound of dry coal.....do....	8.11
Per pound of combustible.....do....	10.15
Efficiency of boiler, including grate.....per cent..	67.12
Coal as fired:	
Per indicated horsepower hour.....pounds..	3.98
Per electrical horsepower hour.....do....	4.92
Dry coal:	
Per indicated horsepower hour.....do....	3.49
Per electrical horsepower hour.....do....	4.30

ANALYSES.

	Test 162.		Test 162.
Proximate.		*Ultimate.*	
Moisture	12.42	Carbon[a]	63.44
Volatile matter	31.83	Hydrogen[a]	4.53
Fixed carbon	40.68	Oxygen[a]	8.03
Ash	15.07	Nitrogen[a]	1.26
	100.00	Sulphur	5.53
Sulphur	4.84	Ash	17.21
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 53, Indiana No. 3, washed.

Size as shipped, nut and slack. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower		189.7
Average B. T. U. gas, per cubic foot		137.2
Total coal fired	pounds..	17,550

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 53.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.97	1.74	1.57
Developed at switch board	1.85	1.63	1.48
Per brake horsepower:			
Available for outside purposes	1.67	1.47	1.34
Developed at engine	1.57	1.39	1.26
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.09	1.84	1.67
Developed at switch board	1.97	1.73	1.57
Per brake horsepower:			
Available for outside purposes	1.78	1.56	1.42
Developed at engine	1.67	1.47	1.33

ANALYSES.

	Test 53.		Test 53.
Coal.		*Gas by volume.*	
Moisture	11.85	Carbon dioxide (CO_2)	10.7
Volatile matter	36.85	Carbon monoxide (CO)	18.1
Fixed carbon	43.15	Hydrogen (H_2)	10.6
Ash	8.15	Methane (CH_4)	2.7
	100.00	Nitrogen (N_2)	57.9
Sulphur	3.04		100.0

WASHING TEST.

Test 115, Indiana No. 3.

Size as shipped, nut and slack. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	50,000
Washed coal	do....	36,000
Refuse	do....	14,000

ANALYSES.

	Test 115.	
	Raw coal.	Washed coal.
Moisture	13.18	15.02
Volatile matter	31.92	.....
Fixed carbon	39.27	.....
Ash	15.63	8.61
Sulphur	4.79	3.25

COKING TEST.

Test 14, Indiana No. 3.

Size as shipped, nut and slack. Size as used, finely crushed.
Remarks.—Burned for 24 hours. Ashed down about 10 inches. No coke produced.

INDIANA NO. 4.

Bituminous coal from mine No. 29, Consolidated Indiana Coal Company, Star City, Sullivan County, Ind., on the Evansville and Terre Haute Railroad.

This sample was loaded under the supervision of Inspector J. S. Burrows and consisted of screenings which had passed through a 1¼-inch bar screen. The tests made on this sample were as follows: Washing test No. 112, coking tests Nos. 6 and 9, steaming tests Nos. 151, 165, and 166, and steaming test on washed coal No. 154.

Two mine samples were taken from this mine for chemical analysis. No. 1807 was obtained at a point in the eighth east entry on the south side of the mine, 4,000 feet southeast of the shaft, and No. 1775 was cut from the face of room 1 off the thirteenth east entry, 3,900 feet north of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1775	1807	1844
Air-drying loss		9.00	8.90	10.80
Proximate.	Moisture	14.86	13.37	13.99
	Volatile matter	31.65	35.06	29.40
	Fixed carbon	46.14	44.15	42.29
	Ash	7.35	7.42	14.32
Ultimate.	Sulphur	2.26	2.10	2.31
	Hydrogen	.....	.....	5.36
	Carbon	.....	.....	57.18
	Nitrogen	.....	.....	1.11
	Oxygen	.....	.....	19.72
Calorific value determined:				
	Calories	6,291	.....	5,732
	British thermal units	11,324	.....	10,318

STEAMING TESTS.

Test 151, Indiana No. 4.

Size as shipped, screenings. Size as used, over 1 inch, 36.5 per cent; ½ inch to 1 inch, 21 per cent; ¼ inch to ½ inch, 15.4 per cent; under ¼ inch, 27.1 per cent. Duration of test, 10.05 hours. Kind of grate, plain.

Test 154, Indiana No. 4, washed.

Size as shipped, screenings. Size as used, over 1 inch, 18.5 per cent; ½ inch to 1 inch, 29.9 per cent; ¼ inch to ½ inch, 24.4 per cent; under ¼ inch, 27.2 per cent. Duration of test, 9.95 hours. Kind of grate, plain.

Test 165, Indiana No. 4.

Size as shipped, screenings. Size as used, over 1 inch, 19 per cent; ½ inch to 1 inch, 22.4 per cent; ¼ inch to ½ inch, 18.6 per cent; under ¼ inch, 40 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 166, Indiana No. 4.

Size as shipped, screenings. Size as used, over 1 inch, 8.1 per cent; ½ inch to 1 inch, 18.3 per cent; ¼ inch to ½ inch, 18.8 per cent; under ¼ inch, 54.8 per cent. Duration of test, 8.80 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 151.	Test 154.	Test 165.	Test 166.
Heating value of coal.....B. T. U. per pound dry coal..	11,977	13,421	11,486	11,693
Force of draft:				
Under stack damper.....inch water..	0.48	0.45	0.61	0.60
Above fire.....do....	.12	.11	.19	.22
Furnace temperature.....°F..	2,023	2,390	2,062	1,870
Dry coal used per square foot of grate surface per hour, pounds.....	18.64	19.21	21.98	19.62
Equivalent water evaporated per square foot of wate -heating surface per hour.....pounds..	2.88	3.40	3.17	2.67
Percentage of rated horsepower of boiler developed.....	80.8	95.3	88.9	74.7
Water apparently evaporated per pound of coal as fired, pounds.....	5.74	6.45	5.94	5.57
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	6.64	7.55	6.94	6.46
Per pound of dry coal.....do....	7.74	8.86	8.05	7.58
Per pound of combustible.....do....	9.57	9.86	10.43	9.86
Efficiency of boiler, including grate.....per cent..	62.41	63.75	67.68	62.60
Coal as fired:				
Per indicated horsepower hour.....pounds..	4.26	3.75	4.08	4.38
Per electrical horsepower hour.....do....	5.26	4.62	5.03	5.40
Dry coal:				
Per indicated horsepower hour.....do....	3.65	3.19	3.51	3.73
Per electrical horsepower hour.....do....	4.51	3.94	4.34	4.60

ANALYSES.

	Test 151.	Test 154.	Test 165.	Test 166.
Proximate.				
Moisture.....	14.24	14.80	13.82	14.79
Volatile matter.....	31.59	33.10	29.12	29.76
Fixed carbon.....	39.96	44.91	39.80	39.69
Ash.....	14.21	7.19	17.26	15.76
	100.00	100.00	100.00	100.00
Sulphur.....	2.52	2.12	2.43	2.52

ANALYSES—continued.

	Test 151.	Test 154.	Test 165.	Test 166.
Ultimate.				
Carbon[a]	66.31	73.41	63.59	64.73
Hydrogen[a]	4.42	4.89	4.24	4.31
Oxygen[a]	8.46	9.35	8.09	8.25
Nitrogen[a]	1.30	1.42	1.23	1.26
Sulphur	2.94	2.49	2.82	2.96
Ash	16.57	8.44	20.03	18.49
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 112, Indiana No. 4.

Size as shipped, screenings. Size as used, screenings (1¼-inch). Jig used, Stewart modified.

Raw coal	pounds..	32,000
Washed coal	do....	24,000
Refuse	do....	8,000

ANALYSES.

	Test 112.	
	Raw coal.	Washed coal.
Moisture	13.99	16.49
Volatile matter	29.40	.....
Fixed carbon	42.29	.....
Ash	14.32	7.25
Sulphur	2.31	1.94

COKING TESTS.

Test 6, Indiana No. 4.

Size as shipped, screenings. Size as used, finely crushed. Raw. Duration of test, 62 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,010
Breeze produced	do....	536
Coke produced	per cent..	50.10
Breeze produced	do....	5.36
Total percentage yield		55.46

Remarks.—Light-gray color. High ash and sulphur. Medium coke.

Test 9, Indiana No. 4, washed.

Size as shipped, screenings. Size as used, finely crushed. Duration of test, 58 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,153
Breeze produced	do....	332
Coke produced	per cent..	51.53
Breeze produced	do....	3.32
Total percentage yield		54.85

Remarks.—Light-gray and silvery color. Ash reduced materially by washing; a little too much sulphur.

ANALYSES.

	Test 6.		Test 9.	
	Coal.	Coke.	Coal.	Coke.
Moisture	14.30	6.31	16.33	0.55
Volatile matter	29.48	1.60	31.89	.38
Fixed carbon	40.96	68.35	44.19	85.91
Ash	15.26	23.74	7.59	13.16
Sulphur	2.60	2.80	2.08	2.06

INDIANA NO. 5.

Bituminous coal from mine No. 33, Consolidated Indiana Coal Company, Hymera, Sullivan County, Ind., on the Evansville and Terre Haute Railroad.

This sample, which consisted of run-of-mine coal, was shipped under the supervision of Inspector J. S. Burrows and was used in making coking test No. 8, steaming tests Nos. 153, 155, and 156, and producer-gas tests Nos. 46 and 47.

Two mine samples were taken in the mine, one of which, No. 1774, came from the second east entry on the north side of the mine, 1,200 feet from the shaft, and the other, No. 1773, from room 16 off the second east entry, 1,600 feet southwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number	per cent..	1773	1774	1859
Air-drying loss	do....	9.10	8.40	7.20
Proximate. Moisture	do....	12.14	12.17	12.03
Proximate. Volatile matter	do....	35.17	35.53	35.65
Proximate. Fixed carbon	do....	43.73	43.14	41.44
Proximate. Ash	do....	8.96	9.16	10.88
Ultimate. Sulphur	do....	3.54	4.66	4.27
Ultimate. Hydrogen	do....	.....	.....	5.50
Ultimate. Carbon	do....	.....	.....	60.73
Ultimate. Nitrogen	do....	.....	.....	1.08
Ultimate. Oxygen	do....	.....	.....	17.54
Calorific value determined:				
Calories		6,398	.....	6,218
British thermal units		11,516	.....	11,192

STEAMING TESTS.

Test 153, Indiana No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 29.0 per cent; ½ inch to 1 inch, 23.2 per cent; ¼ inch to ½ inch, 16.2 per cent; under ¼ inch, 31.6 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 155, Indiana No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 27.7 per cent; ½ inch to 1 inch, 20.0 per cent; ¼ inch to ½ inch, 20.4 per cent; under ¼ inch, 31.9 per cent. Duration of test, 9.98 hours. Kind of grate, plain.

Test 156, Indiana No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 33.7 per cent; ½ inch to 1 inch, 23.2 per cent; ¼ inch to ½ inch, 15.4 per cent; under ¼ inch, 27.7 per cent. Duration of test, 9.92 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 153.	Test 155.	Test 156.
Heating value of coal	B. T. U. per pound dry coal..	12,564	12,546	12,730
Force of draft:				
Under stack damper	inch water..	0.51	0.50	0.53
Above fire	do....	.22	.18	.18
Furnace temperature	°F..	2,391	2,223	2,317
Dry coal used per square foot of grate surface per hour	pounds..	19.21	17.41	19.14
Equivalent water evaporated per square foot of water-heating surface per hour	pounds..	3.16	2.90	3.10
Percentage of rated horsepower of boiler developed		88.6	81.3	87.0
Water apparently evaporated per pound of coal as fired	pounds..	6.26	6.32	6.20
Water evaporated from and at 212° F.:				
Per pound of coal as fired	do....	7.30	7.36	7.23
Per pound of dry coal	do....	8.24	8.35	8.13
Per pound of combustible	do....	9.61	9.91	9.49

MISCELLANEOUS ITEMS—continued.

	Test 153.	Test 155.	Test 156.
Efficiency of boiler, including grate.....per cent..	63.25	64.27	61.67
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.87	3.84	3.91
Per electrical horsepower hour.....do....	4.78	4.74	4.83
Dry coal:			
Per indicated horsepower hour.....do....	3.43	3.39	3.48
Per electrical horsepower hour.....do....	4.24	4.18	4.30

ANALYSES.

	Test 153.	Test 155.	Test 156.		Test 153.	Test 155.	Test 156.
Proximate.				*Ultimate.*			
Moisture.....	11.31	11.83	11.01	Carbon[a].....	68.25	67.95	69.06
Volatile matter....	36.36	34.23	35.02	Hydrogen[a].....	4.68	4.66	4.73
Fixed carbon.....	41.29	42.27	43.01	Oxygen[a].....	7.68	7.66	7.79
Ash.....	11.04	11.67	10.96	Nitrogen[a].....	1.22	1.21	1.22
	100.00	100.00	100.00	Sulphur.....	5.72	5.29	4.89
Sulphur.....	5.07	4.65	4.35	Ash.....	12.45	13.23	12.31
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TESTS.

Test 46, Indiana No. 5.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 30 hours.

Average electrical horsepower..... 199.0
Average B. T. U. gas, per cubic foot..... 136.7
Total coal fired.....pounds.. 11,850

Test 47, Indiana No. 5.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower..... 202.2
Average B. T. U. gas, per cubic foot..... 145.0
Total coal fired.....pounds.. 14,250

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 46.			Test 47.		
	Coal as fired.	Dry coal.	Combustible..	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:						
Available for outside purposes.....	2.12	1.91	1.64	1.51	1.35	1.20
Developed at switch board	1.99	1.79	1.54	1.41	1.26	1.12
Per brake horsepower:						
Available for outside purposes.....	1.80	1.62	1.39	1.29	1.15	1.02
Developed at engine.....	1.69	1.52	1.31	1.20	1.07	.95
Equivalent used by producer plant.						
Per electrical horsepower:						
Available for outside purposes.....	2.29	2.06	1.78	1.62	1.45	1.28
Developed at switch board.....	2.15	1.93	1.66	1.51	1.35	1.19
Per brake horsepower:						
Available for outside purposes.....	1.95	1.75	1.51	1.37	1.23	1.09
Developed at engine.....	1.83	1.64	1.41	1.28	1.15	1.01

Note.—Producer-gas tests 46 and 47 are on the same coal. Test 46 was cut short owing to the clogging up of the economiser.

ANALYSES.

	Test 46.	Test 47.		Test 46.	Test 47.
Coal.			*Gas by volume.*		
Moisture	10.02	10.49	Carbon dioxide (CO_2)	12.0	10.1
Volatile matter	35.49	35.90	Carbon monoxide (CO)	15.2	18.8
Fixed carbon	41.98	43.25	Hydrogen (H_2)	11.8	11.5
Ash	12.51	10.36	Methane (CH_4)	3.0	2.9
	100.00	100.00	Nitrogen (N_2)	58.0	56.7
Sulphur	6.04	4.14		100.0	100.0

COKING TEST.

Test 8, Indiana No. 5.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 49 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,340
Breeze produced	do....	232
Coke produced	per cent..	53.40
Breeze produced	do....	2.32
Total percentage yield		55.72

Remarks.—Light-gray and silvery color. Good, strong coke. High ash and sulpher.

ANALYSES.

	Test 8.	
	Coal.	Coke.
Moisture	10.74	0.76
Volatile matter	36.71	.54
Fixed carbon	41.95	81.29
Ash	10.60	17.41
Sulphur	4.61	4.21

INDIANA NO. 6.

Bituminous coal from mine No 34, Consolidated Indiana Coal Company, Hymera, Sullivan County, Ind., on the Evansville and Terre Haute Railroad.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. S. Burrows. It was used in making washing test No. 113, coke test No. 12, steaming test No. 157, steaming test on washed coal No. 159, and producer-gas test No. 49.

Two mine samples were selected from widely separated points in this mine. No. 1772 came from room 2, off the second east entry on the south side, 300 feet southeast of the shaft; No. 1776 from the main north entry, 425 feet north of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1772	1776	1875
Air-drying loss		7.20	4.70	5.20
Proximate.	Moisture	10.45	9.22	10.80
	Volatile matter	38.62	37.76	36.09
	Fixed carbon	41.35	41.85	40.49
	Ash	9.58	11.17	12.62
Ultimate.	Sulphur	4.04	3.94	4.39
	Hydrogen	.....	.....	5.46
	Carbon	.....	.....	60.88
	Nitrogen	.....	.....	1.13
	Oxygen	.....	.....	15.52
Calorific value determined:				
	Calories	6,525	.....	6,214
	British thermal units	11,745	.....	11,185

STEAMING TESTS.

Test 157, Indiana No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 29.9 per cent; ½ inch to 1 inch, 19.9 per cent; ¼ inch to ½ inch, 14.2 per cent; under ¼ inch, 36 per cent. Duration of test, 9.97 hours. Kind of grate, plain.

Test 159, Indiana No. 6, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 39.8 per cent; ½ inch to 1 inch, 27.1 per cent; ¼ inch to ½ inch, 15.8 per cent; under ¼ inch, 17.3 per cent. Duration of test, 9.92 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 157.	Test 159.
Heating value of coal.....B. T. U. per pound dry coal..	12,505	13,091
Force of draft:		
Under stack damper.....inch water..	0.49	0.43
Above fire.....do....	.15	.11
Furnace temperature.....°F..	2,410	2,522
Dry coal used per square foot of grate surface per hour.....pounds..	18.59	21.40
Equivalent water evaporated per square foot of water-heating surface per hour, pounds.....	3.03	3.45
Percentage of rated horsepower of boiler developed.....	84.9	96.7
Water apparently evaporated per pound of coal as fired.....pounds..	6.30	6.15
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	7.30	7.15
Per pound of dry coal.....do....	8.16	8.06
Per pound of combustible.....do....	9.72	9.18
Efficiency of boiler, including grate.....per cent..	63.02	59.46
Coal as fired:		
Per indicated horsepower hour.....pounds..	3.87	3.96
Per electrical horsepower hour.....do....	4.78	4.88
Dry coal:		
Per indicated horsepower hour.....do....	3.47	3.51
Per electrical horsepower hour.....do....	4.28	4.33

ANALYSES.

	Test 157.	Test 159.		Test 157.	Test 159.
Proximate.			*Ultimate.*		
Moisture	10.51	11.27	Carbon[a]	68.03	71.77
Volatile matter	34.80	37.90	Hydrogen[a]	4.76	5.02
Fixed carbon	41.93	41.20	Oxygen[a]	6.61	7.01
Ash	12.76	9.63	Nitrogen[a]	1.26	1.33
	100.00	100.00	Sulphur	5.08	4.02
Sulphur	4.55	3.57	Ash	14.26	10.85
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 49, Indiana No. 6.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	199.6
Average B. T. U. gas, per cubic foot	150.9
Total coal fired.....pounds..	17,850

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 49.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.89	1.68	1.45
Developed at switch board	1.79	1.59	1.37
Per brake horsepower:			
Available for outside purposes	1.61	1.43	1.23
Developed at engine	1.52	1.35	1.16
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.05	1.83	1.57
Developed at switch board	1.94	1.73	1.49
Per brake horsepower:			
Available for outside purposes	1.74	1.55	1.33
Deevloped at engine	1.65	1.47	1.26

ANALYSES.

	Test 49.		Test 49.
Coal.		*Gas by volume.*	
Moisture	10.89	Carbon dioxide (CO_2)	9.8
Volatile matter	36.19	Carbon monoxide (CO)	18.1
Fixed carbon	40.43	Hydrogen (H_2)	12.8
Ash	12.49	Methane (CH_4)	2.4
	100.00	Nitrogen (N_2)	56.9
Sulphur	4.71		100.00

WASHING TEST.

Test 113, Indiana No. 6.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	24,000
Washed coal	do....	19,100
Refuse	do....	4,900

ANALYSES.

	Test 113.	
	Raw coal.	Washed coal.
Moisture	10.80	11.65
Volatile matter	36.09	.....
Fixed carbon	40.49	.....
Ash	12.62	9.83
Sulphur	4.39	3.49

COKING TEST.

Test 12, Indiana No. 6, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 49 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,434
Breeze produced	do....	501
Coke produced	per cent..	54.34
Breeze produced	do....	5.01
Total percentage yield		59.35

Remarks.—Light-gray and silvery color. Good coke, but ash and sulphur high.

ANALYSES.

	Test 12.	
	Coal.	Coke.
Moisture	12.39	0.75
Volatile matter	36.77	.73
Fixed carbon	40.85	81.90
Ash	9.99	16.62
Sulphur	3.59	3.16

INDIANA NO. 7.

Bituminous coal from Little's mine, S. W. Little Coal Company, Littles, Pike County, Ind., on the Evansville and Terre Haute Railroad.

Two samples of coal were shipped from this mine under the supervision of Inspector W. J. Von Borries, as follows: Indiana No. 7 A was made up of lump coal which had been passed over a 1⅛-inch screen. This sample was used in making washing test No. 114, coking test No. 13, steaming test No. 158, and producer-gas test No. 51. Indiana No. 7 B consisted of screenings which had passed through a 1⅛-inch screen and was used in making steaming tests Nos. 164 and 176, the rest being reserved for briquette experiments.

Two mine samples were taken in this mine. No. 1824 was obtained at a point 2,000 feet southeast of the shaft, off the eighth south entry, and No. 1825 at a point in the main entry 2,600 feet east of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample A.	Car sample B.
Laboratory number		1824	1825	1881	1882
Air-drying loss		6.40	6.20	3.60	8.60
Proximate.	Moisture	10.18	9.99	8.90	11.12
	Volatile matter	38.86	37.86	38.52	36.98
	Fixed carbon	42.84	44.18	43.37	42.55
	Ash	8.12	7.97	9.21	9.35
Ultimate.	Sulphur	3.96	3.25	3.74	3.78
	Hydrogen	.....	.....	5.61	5.63
	Carbon	.....	.....	65.54	63.01
	Nitrogen	.....	.....	1.20	1.13
	Oxygen	.....	.....	14.70	17.10
Calorific value determined:					
Calories		6,767	.....	6,671	6,416
British thermal units		12,181	.....	12,008	11,549

STEAMING TESTS.

Test 158, Indiana No. 7 A.

Size as shipped, lump, egg, and nut. Size as used, over 1 inch, 44.3 per cent; ½ inch to 1 inch, 25 per cent; ¼ inch to ½ inch, 14.2 per cent; under ¼ inch, 16.5 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 164, Indiana No. 7 B.

Size as shipped, screenings. Size as used, over 1 inch, 5.6 per cent; ½ inch to 1 inch, 25.3 per cent; ¼ inch to ½ inch, 25.8 per cent; under ¼ inch, 43.3 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

Test 176, Indiana No. 7 B.

Size as shipped, screenings. Size as used, over 1 inch, 5.1 per cent; ½ inch to 1 inch, 23.1 per cent; ¼ inch to ½ inch, 24.4 per cent; under ¼ inch, 47.4 per cent. Duration of test, 10.07 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 158.	Test 164.	Test 176.
Heating value of coal.....B. T. U. per pound dry coal..	13,248	12,838	12,710
Force of draft:			
Under stack damper.....inch water..	0.44	0.62	0.56
Above fire.....do....	.12	.23	.17
Furnace temperature.....°F..	2,579	1,880	2,033
Dry coal used per square foot of grate surface per hour.....pounds..	19.85	19.01	17.48
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.45	2.69	2.80
Percentage of rated horsepower of boiler developed.....	96.9	75.5	78.6
Water apparently evaporated per pound of coal as fired.....pounds..	6.80	6.05	6.27
Water evaporated from and at 212 °F.:			
Per pound of coal as fired.....do....	7.95	7.06	7.27
Per pound of dry coal.....do....	8.72	7.91	8.02
Per pound of combustible.....do....	9.83	9.14	9.32
Efficiency of boiler, including grate.....per cent..	63.56	59.49	60.94
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.56	4.01	3.89
Per electrical horsepower hour.....do....	4.39	4.95	4.80
Dry coal:			
Per indicated horsepower hour.....do....	3.24	3.57	3.53
Per electrical horsepower hour.....do....	4.00	4.41	4.35

ANALYSES.

	Test 158.	Test 164.	Test 176.		Test 158.	Test 164.	Test 176.
Proximate.				*Ultimate.*			
Moisture	8.81	10.74	9.37	Carbon[a]	72.37	70.01	69.21
Volatile matter	38.98	37.78	38.40	Hydrogen[a]	5.10	4.88	4.82
Fixed carbon	43.37	41.27	41.18	Oxygen[a]	7.49	8.03	7.94
Ash	8.84	10.21	11.05	Nitrogen[a]	1.33	1.25	1.24
	100.00	100.00	100.00	Sulphur	4.02	4.39	4.60
Sulphur	3.67	3.92	4.17	Ash	9.69	11.44	12.19
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 51, Indiana No. 7 A.

Size as shipped, lump, egg, and nut. Size as used, over 1 inch, 69 per cent; ½ inch to 1 inch, 13 per cent; ¼ inch to ½ inch, 7 per cent; under ¼ inch, 11 per cent. Duration of test, 45 hours.

Average electrical horsepower	198.1
Average B. T. U. gas, per cubic foot	158.5
Total coal fired, pounds	13,650

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 51.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.61	1.49	1.32
Developed at switch board	1.53	1.41	1.25
Per brake horsepower:			
Available for outside purposes	1.37	1.26	1.12
Developed at engine	1.30	1.20	1.06
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.74	1.60	1.42
Developed at switch board	1.65	1.52	1.35
Per brake horsepower:			
Available for outside purposes	1.47	1.36	1.20
Developed at engine	1.40	1.26	1.14

ANALYSES.

	Test 51.		Test 51.
Coal.		*Gas by volume.*	
Moisture	7.73	Carbon dioxide (CO_2)	8.2
Volatile matter	39.19	Carbon monoxide (CO)	22.2
Fixed carbon	42.47	Hydrogen (H_2)	11.9
Ash	10.61	Methane (CH_4)	3.2
	100.00	Nitrogen (N_2)	54.5
Sulphur	5.20		100.0

WASHING TEST.

Test 114, Indiana No. 7 A.

Size as shipped, lump, egg, and nut. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	14,000
Washed coal	do....	12,240
Refuse	do....	1,760

ANALYSES.

	Test 114.	
	Raw coal.	Washed coal.
Moisture	8.90	10.16
Volatile matter	38.52	.....
Fixed carbon	43.37	.....
Ash	9.21	7.89
Sulphur	3.74	3.24

COKING TEST.

Test 13, Indiana No. 7 A, washed.

Size as shipped, lump, egg, and nut. Size as used, finely crushed. Duration of test, 112 hours.

Coal charged	pounds..	12,240
Coke produced	do....	6,993
Breeze produced	do....	640
Coke produced	per cent..	57.13
Breeze produced	do....	5.23
Total percentage yield		62.36

Remarks.—Light-gray and silvery color. Somewhat brittle. High ash and sulphur.

ANALYSES.

	Test 13.	
	Coal.	Coke.
Moisture	10.33	1.13
Volatile matter	38.35	2.35
Fixed carbon	42.93	83.23
Ash	8.39	13.29
Sulphur	3.12	2.69

INDIANA NO. 8.

Bituminous coal from Deep Vein mine, Deep Vein Coal Company, 2 miles west of Terre Haute, Vigo County, Ind., on the Vandalia Railroad.

The sample for testing was shipped as lump coal, which at this mine is run over a 1¼-inch bar screen. The coal was inspected by Inspector J. W. Groves, and was used in making washing test No. 118 steaming tests Nos. 182, 183, and 185, steaming test on washed coal No. 184, and producer-gas test No. 57.

Two mine samples were taken. No. 1828 came from room 8 off the fourth south entry on the east side, 700 feet southeast of the shaft, and No. 1829 came from the sixth west entry on the north side, 800 feet northwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1828	1829	2037
Air-drying loss		7.40	8.00	4.60
Proximate.	Moisture	10.68	11.13	9.55
	Volatile matter	37.17	36.86	36.19
	Fixed carbon	39.91	41.80	43.65
	Ash	12.24	10.21	10.61
Ultimate.	Sulphur	4.38	3.76	3.72
	Hydrogen	.....	.....	5.49
	Carbon	.....	.....	64.08
	Nitrogen	.....	.....	1.08
	Oxygen	.....	.....	15.02
Calorific value determined:				
	Calories	6,256	.....	6,533
	British thermal units	11,261	.....	11,759

STEAMING TESTS.

Test 182, Indiana No. 8.

Size as shipped, lump. Size as used, over 1 inch, 30.5 per cent; ½ inch to 1 inch, 23.1 per cent; ¼ inch to ½ inch, 16.7 per cent; under ¼ inch 29.7 per cent. Duration of test, 9.98 hours. Kind of grate, plain.

Test 183, Indiana No. 8.

Size as shipped, lump. Size as used, over 1 inch, 39.5 per cent; ½ inch to 1 inch, 23.3 per cent; ¼ inch to ½ inch, 13.4 per cent; under ¼ inch, 23.8 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 185, Indiana No. 8.

Size as shipped, lump. Size as used, over 1 inch, 27.7 per cent; ½ inch to 1 inch, 21.4 per cent; ¼ inch to ½ inch, 17.2 per cent; under ¼ inch, 33.7 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 184, Indiana No. 8, washed.

Size as shipped, lump. Size as used, over 1 inch, 20.1 per cent; ½ inch to 1 inch, 29.9 per cent; ¼ inch to ½ inch, 24.3 per cent, under ¼ inch, 25.7 per cent. Duration of test, 10 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 182.	Test 183.	Test 185.	Test 184.
Heating value of coal.....B. T. U. per pound dry coal..	12,838	12,587	12,622	13,091
Force of draft:				
Under stack damper.....inch water..	0.49	0.41	0.51	0.43
Above fire.....do....	.16	.13	.16	.10
Furnace temperature.....°F..	2,384	2,279	2,304	2,354
Dry coal used per square foot of grate surface per hour, pounds	19.78	17.24	19.63	19.78
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.22	2.88	3.18	3.46
Percentage of rated horsepower of boiler developed	90.2	80.7	89.0	97.0
Water apparently evaporated per pound of coal as fired, pounds	6.34	6.43	6.24	6.61
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	7.38	7.48	7.28	7.72
Per pound of dry coal.....do....	8.15	8.36	8.10	8.76
Per pound of combustible.....do....	9.52	9.85	9.63	9.94
Efficiency of boiler, including grate.....per cent..	61.31	64.14	61.97	64.62
Coal as fired:				
Per indicated horsepower hour.....pounds..	3.83	3.78	3.89	3.66
Per electrical horsepower hour.....do....	4.73	4.67	4.80	4.52
Dry coal:				
Per indicated horsepower hour.....do....	3.47	3.38	3.49	3.23
Per electrical horsepower hour.....do....	4.28	4.18	4.31	3.99

ANALYSES.

	Test 182.	Test 183.	Test 185.	Test 184.
Proximate.				
Moisture	9.37	10.54	10.12	11.87
Volatile matter	36.93	35.48	35.55	37.17
Fixed carbon	42.33	41.46	41.44	41.67
Ash	11.37	12.52	12.89	9.29
	100.00	100.00	100.00	100.00
Sulphur	4.05	4.22	3.54	2.87
Ultimate.				
Carbon [a]	69.86	68.42	68.80	72.57
Hydrogen [a]	4.83	4.73	4.76	5.01
Oxygen [a]	7.11	6.98	7.00	7.39
Nitrogen [a]	1.18	1.15	1.16	1.23
Sulphur	4.47	4.72	3.94	3.26
Ash	12.55	14.00	14.34	10.54
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 57, Indiana No. 8.

Size as shipped, lump. Size as used, over 1 inch, 78 per cent; ½ inch to 1 inch, 9 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 8 per cent. Duration of test, 59 hours.

Average electrical horsepower	209.2
Average B. T. U. gas per cubic foot	151.5
Total coal fired ..... pounds..	15,300

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 57.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.61	1.46	1.28
Developed at switch board	1.53	1.39	1.22
Per brake horsepower:			
Available for outside purposes	1.37	1.24	1.09
Developed at engine	1.30	1.18	1.03
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.70	1.54	1.35
Developed at switch board	1.61	1.46	1.28
Per brake horsepower:			
Available for outside purposes	1.45	1.31	1.15
Developed at engine	1.37	1.24	1.09

ANALYSES.

	Test 57.		Test 57.
Coal.		*Gas by volume.*	
Moisture	9.21	Carbon dioxide (CO_2)	9.5
Volatile matter	36.78	Carbon monoxide (CO)	20.1
Fixed carbon	42.66	Hydrogen (H_2)	11.3
Ash	11.35	Methane (CH_4)	2.8
	100.00	Nitrogen (N_2)	56.3
Sulphur	3.80		100.0

WASHING TEST.

Test 118, Indiana No. 8.

Size as shipped, lump. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	16,000
Washed coal	do....	15,080
Refuse	do....	920

ANALYSES.

	Test 118.	
	Raw coal.	Washed coal.
Moisture	9.55	11.76
Volatile matter	36.19	.....
Fixed carbon	43.65	.....
Ash	10.61	9.52
Sulphur	3.72	3.18

INDIANA NO. 9.

Bituminous coal from Red Bird mine, Fauvre Coal Company, Macksville, Vigo County, Ind., on the Vandalia Railroad.

Two separate samples were shipped under the supervision of Inspector W. J. Von Borries for testing purposes, as follows: Indiana No. 9 A consisted of lump coal which had been passed over a 1¼-inch screen. The following tests were made on this sample: Coking test No. 16, steaming tests Nos. 168 and 169, and producer-gas test No. 52. Indiana No. 9 B was made up of run-of-mine coal. The tests made on this sample were washing test No. 117, coking tests Nos. 17 and 18, and steaming test No. 174.

Two mine samples were collected from the mine for chemical analysis. No. 1848 was taken in room 18 off the fifth north entry, 900 feet north of the shaft, and No. 1849 from a point 2,000 feet N. 10° E., in the fourth east entry off the sixth north entry.

CHEMICAL ANALYSES.

		Mine sample.		Car sample A.	Car sample B.
Laboratory number		1848	1849	1973	1960
Air-drying loss		10.80	11.00	8.00	10.70
Proximate.	Moisture	13.73	14.33	12.82	13.53
	Volatile matter	35.54	35.18	34.80	34.80
	Fixed carbon	42.08	42.02	42.08	40.91
	Ash	8.65	8.47	10.30	10.76
Ultimate.	Sulphur	3.00	2.70	3.27	3.15
	Hydrogen			5.66	5.78
	Carbon			61.16	59.64
	Nitrogen			1.03	1.06
	Oxygen			18.58	19.61
Calorific value determined:					
	Calories	6,311		6,177	6,082
	British thermal units	11,360		11,119	10,948

STEAMING TESTS.

Test 168, Indiana No. 9 A.

Size as shipped, lump. Size as used, over 1 inch, 40.6 per cent; ½ inch to 1 inch, 24.2 per cent; ¼ inch to ½ inch, 15 per cent; under ¼ inch, 20.2 per cent. Duration of test, 9.92 hours. Kind of grate, rocking.

Test 169, Indiana No. 9 A.

Size as shipped, lump. Size as used, over 1 inch, 31.2 per cent; ½ inch to 1 inch, 21.6 per cent; ¼ inch to ½ inch, 16 per cent; under ¼ inch, 31.2 per cent. Duration of test, 10.02 hours. Kind of grate, rocking.

Test 174, Indiana No. 9 B.

Size as shipped, run of mine. Size as used, over 1 inch 23.8 per cent; ½ inch to 1 inch, 21.7 per cent; ¼ inch to ½ inch, 18.2 per cent; under ¼ inch, 36.3 per cent. Duration of test, 6.7 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 168.	Test 169.	Test 174.
Heating value of coal, B. T. U. per pound dry coal	12,181	12,447	12,740
Force of draft:			
Under stack damper, inch water	.53	.49	.56
Above fire, do	.12	.13	.15
Furnace temperature, °F.	2,349	2,239	2,064
Dry coal used per square foot of grate surface per hour, pounds	23.87	21.13	19.19
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.62	3.26	3.14
Percentage of rated horsepower of boiler developed	101.4	91.5	87.9
Water apparently evaporated per pound of coal as fired, pounds	6.37	6.46	6.23
Water evaporated from and at 212 °F.:			
Per pound of coal as fired, do	7.44	7.54	7.24
Per pound of dry coal, do	8.45	8.62	8.19
Per pound of combustible, do	10.17	10.18	9.50
Efficiency of boiler, including grate, per cent	66.99	66.88	62.08
Coal as fired:			
Per indicated horsepower hour, pounds	3.80	3.75	3.91
Per electrical horsepower hour, do	4.69	4.63	4.82
Dry coal:			
Per indicated horsepower hour, do	3.35	3.28	3.45
Per electrical horsepower hour, do	4.14	4.05	4.26

ANALYSES.

	Test 168.	Test 169.	Test 174.		Test 168.	Test 169.	Test 174.
Proximate.				*Ultimate.*			
Moisture	11.99	12.53	11.62	Carbon [a]	66.85	68.40	69.48
Volatile matter	34.76	34.80	36.33	Hydrogen [a]	4.64	4.74	4.98
Fixed carbon	39.88	40.73	41.33	Oxygen [a]	7.86	8.03	8.84
Ash	13.37	11.94	10.72	Nitrogen [a]	1.12	1.16	1.23
	100.00	100.00	100.00	Sulphur	4.34	4.02	3.34
Sulphur	3.82	3.52	2.95	Ash	15.19	13.65	12.13
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 52, Indiana No. 9 A.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 78 per cent; ½ inch to 1 inch, 10 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 7 per cent. Duration of test, 45 hours.

Average electrical horsepower	195.8
Average B. T. U. gas, per cubic foot	151.8
Total coal fired, pounds	15,450

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 52.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.84	1.61	1.43
Developed at switch board	1.75	1.53	1.36
Per brake horsepower:			
Available for outside purposes	1.57	1.37	1.21
Developed at engine	1.49	1.30	1.16
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.94	1.70	1.50
Developed at switch board	1.84	1.61	1.43
Per brake horsepower:			
Available for outside purposes	1.65	1.44	1.27
Developed at engine	1.57	1.37	1.21

ANALYSES.

	Test 52.		Test 52.
Coal.		*Gas by volume.*	
Moisture	12.52	Carbon dioxide (CO_2)	10.6
Volatile matter	36.13	Carbon monoxide (CO)	18.0
Fixed carbon	41.25	Hydrogen (H_2)	11.5
Ash	10.10	Methane (CH_4)	2.8
	100.00	Nitrogen (N_2)	57.1
Sulphur	2.76		100.00

WASHING TEST.

Test 117, Indiana No. 9 B.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds...	18,000
Washed coal	do....	15,460
Refuse	do....	2,540

ANALYSES.

	Test 117.	
	Raw coal.	Washed coal.
Moisture	13.53	14.55
Volatile matter	34.80	.....
Fixed carbon	40.91	.....
Ash	10.76	8.14
Sulphur	3.15	2.56

COKING TESTS.

Test 16, Indiana No. 9 A.

Size as shipped over 1¼ inches. Size as used, finely crushed. Raw. Duration of test, 90 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,034
Breeze produced	do....	455
Coke produced	per cent..	58.62
Breeze produced	do....	3.79
Total percentage yield		62.41

Remarks.—Light-gray and silvery color. Somewhat brittle. High ash and sulphur.

Test 17, Indiana No. 9 B.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 112 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,006
Breeze produced	do....	464
Coke produced	per cent..	58.38
Breeze produced	do....	3.87
Total percentage yield		62.25

Remarks.—Light gray and silvery. Fingered coke. Heavy. High ash and sulphur.

Test 18, Indiana No. 9 B, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 90 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,915
Breeze produced	do....	442
Coke produced	per cent..	57.63
Breeze produced	do....	3.68
Total percentage yield		61.31

Remarks.—Light-gray and silvery color. Coal needs oven with bottom flues. Of 3 charges of Indiana No. 9 none could be made to coke entirely to bottom. High ash and sulphur. Not much improved by washing.

ANALYSES.

	Test 16.		Test 17.		Test 18.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	12.30	0.81	12.51	0.68	14.14	0.91
Volatile matter	34.96	2.00	35.65	2.85	36.70	.97
Fixed carbon	41.62	78.74	40.48	78.44	40.90	84.60
Ash	11.12	18.45	11.36	18.03	8.26	13.52
Sulphur	3.41	3.41	3.26	3.50	2.61	2.24

INDIANA NO. 10.

Bituminous coal from mine of Park County Coal Company, Rosedale, Park County, Ind., on the Vandalia Railroad.

A sample of lump coal (over 1¼-inch diamond bar screen) was shipped under the supervision of Inspector J. W. Groves and was used in making washing test No. 116, steaming test No. 167, and steaming test on washed coal No. 177.

Of the two mine samples taken, No. 1853 is from the sixteenth south entry, 3,000 feet southeast of the shaft, and No. 1854 is from the eighteenth north entry, 3,000 feet northeast of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1853	1854	1979
Air-drying loss		8.60	9.60	8.10
Proximate.	Moisture	11.54	12.26	10.72
	Volatile matter	39.49	38.62	39.29
	Fixed carbon	39.35	40.80	41.42
	Ash	9.62	8.32	8.57
	Sulphur	4.41	4.71	3.83
Ultimate.	Hydrogen	.....	.....	5.86
	Carbon	.....	.....	63.48
	Nitrogen	.....	.....	1.16
	Oxygen	.....	.....	17.10
Calorific value determined:				
	Calories	6,475	.....	6,537
	British thermal units	11,655	.....	11,767

STEAMING TESTS.

Test 167, Indiana No. 10.

Size as shipped, lump. Size as used, over 1 inch, 27.5 per cent; ½ inch to 1 inch, 25.8 per cent; ¼ inch to ½ inch, 19.2 per cent; under ¼ inch, 27.5 per cent. Duration of test, 10.05 hours. Kind of grate, rocking.

Test 177, Indiana No. 10, washed.

Size as shipped, lump. Size as used, over 1 inch, 26.2 per cent; ½ inch to 1 inch, 33.6 per cent; ¼ inch to ½ inch, 24.6 per cent; under ¼ inch, 15.6 per cent. Duration of test, 10 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 167.	Test 177.
Heating value of coal ..... B. T. U. per pound dry coal..	12,866	13,595
Force of draft:		
Under stack damper ..... inch water..	0.60	0.45
Above fire ..... do..	.18	.09
Furnace temperature ..... °F..	2,201	2,473
Dry coal used per square foot of grate surface per hour ..... pounds..	22.85	23.05
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.55	3.76
Percentage of rated horsepower of boiler developed	99.4	105.3
Water apparently evaporated per pound of coal as fired ..... pounds..	6.63	6.25
Water evaporated from and at 212° F.:		
Per pound of coal as fired ..... do....	7.74	7.27
Per pound of dry coal ..... do....	8.66	8.17
Per pound of combustible ..... do....	10.01	8.89
Efficiency of boiler, including grate ..... per cent..	65.00	58.03

MISCELLANEOUS ITEMS—continued.

	Test 167.	Test 177.
Coal as fired:		
Per indicated horsepower hour.....pounds..	3.65	3.89
Per electrical horsepower hour.....do....	4.51	4.80
Dry coal:		
Per indicated horsepower hour.....do....	3.27	3.46
Per electrical horsepower hour.....do....	4.03	4.27

ANALYSES.

	Test 167.	Test 177.		Test 167.	Test 177.
Proximate.			*Ultimate.*		
Moisture	10.60	10.98	Carbon[a]	69.32	73.54
Volatile matter	37.90	41.13	Hydrogen[a]	5.10	5.40
Fixed carbon	41.34	41.65	Oxygen[a]	8.25	8.78
Ash	10.16	6.24	Nitrogen[a]	1.26	1.34
	100.00	100.00	Sulphur	4.71	3.93
Sulphur	4.21	3.50	Ash	11.36	7.01
				100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 116, Indiana No. 10.

Size as shipped, lump. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal.....pounds..	18,000
Washed coal.....do....	15,300
Refuse.....do....	2,700

ANALYSES.

	Test 116.	
	Raw coal.	Washed coal.
Moisture	10.72	10.67
Volatile matter	39.29	.....
Fixed carbon	41.42	.....
Ash	8.57	6.15
Sulphur	3.83	3.34

INDIANA NO. 11.

Bituminous coal from mine No. 4, Island Coal Company, Dugger, Sullivan County, Ind., on the Vandalia Railroad.

The sample was shipped as lump coal (over 1½-inch and 3-inch screens) and loaded under the supervision of Inspector J. W. Groves. It was used in making coking test No. 51; steaming tests Nos. 233, 234, and 235, and producer-gas test No. 61.

Two mine samples were taken for chemical analysis, one of which, No. 1883, was from room 1, first west entry, 600 feet northwest of the shaft, and the other, No. 1884, from room 8, *first east entry,* 500 feet northeast of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1883	1884	2087
Air-drying loss		10.60	9.60	4.00
Proximate.	Moisture	14.23	12.62	12.15
	Volatile matter	33.04	34.92	33.48
	Fixed carbon	47.01	45.48	46.23
	Ash	5.72	6.98	8.14
Ultimate.	Sulphur	.89	2.35	1.41
	Hydrogen	.....	.....	5.46
	Carbon	.....	.....	64.92
	Nitrogen	.....	.....	1.38
	Oxygen	.....	.....	18.69
Calorific value determined:				
	Calories	6,512	.....	6,534
	British thermal units	11,722	.....	11,761

STEAMING TESTS.

Test 233, Indiana No. 11.

Size as shipped, lump. Size as used, over 1 inch, 27.4 per cent; ½ inch to 1 inch, 25.1 per cent; ¼ inch to ½ inch, 18.6 per cent; under ¼ inch, 28.9 per cent. Duration of test, 9.65 hours. Kind of grate, rocking.

Test 234, Indiana No. 11.

Size as shipped, lump. Size as used, over 1 inch, 22.1 per cent; ½ inch to 1 inch, 19.9 per cent; ¼ inch to ½ inch, 19.2 per cent; under ¼ inch, 38.8 per cent. Duration of test, 9.62 hours. Kind of grate, rocking.

Test 235, Indiana No. 11.

Size as shipped, lump. Size as used, over 1 inch 20.8 per cent; ½ inch to 1 inch, 19 per cent; ¼ inch to ½ inch, 19.4 per cent; under ¼ inch, 40.8 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 233.	Test 234.	Test 235.
Heating value of coal.....B. T. U. per pound dry coal..	13,423	13,333	13,473
Force of draft:			
Under stack damper.....inch water..	0.51	0.48	0.50
Above fire.....do. ..	.11	.12	.15
Furnace temperature.....°F..	2,577	2,378	2,494
Dry coal used per square foot of grate surface per hour.....pounds..	22.80	20.22	21.18
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.66	3.66	3.43
Percentage of rated horsepower of boiler developed.....	102.5	91.4	96.1
Water apparently evaporated per pound of coal as fired.....pounds..	6.61	6.71	6.66
Water evaporated from and at 212 °F.:			
Per pound of coal as fired.....do....	7.88	7.99	7.94
Per pound of dry coal.....do....	8.94	8.99	9.03
Per pound of combustible.....do....	9.98	10.06	10.00
Efficiency of boiler, including grate.....per cent..	64.32	65.11	64.72
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.59	3.54	3.56
Per electrical horsepower hour..... .do....	4.43	4.37	4.40
Dry coal:			
Per indicated horsepower hour.....do....	3.16	3.15	3.13
Per electrical horsepower hour.....do....	3.91	3.89	3.87

ANALYSES.

	Test 233.	Test 234.	Test 235.		Test 233.	Test 234.	Test 235.
Proximate.				*Ultimate.*			
Moisture	11.93	11.15	12.14	Carbon[a]	74.07	73.55	74.38
Volatile matter	33.01	33.18	31.29	Hydrogen[a]	4.69	4.66	4.71
Fixed carbon	47.16	47.23	48.83	Oxygen[a]	8.99	8.95	9.06
Ash	7.90	8.44	7.74	Nitrogen[a]	1.58	1.56	1.58
				Sulphur	1.70	1.78	1.46
	100.00	100.00	100.00	Ash	8.97	9.50	8.81
Sulphur	1.50	1.58	1.28				
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 61, Indiana No. 11.

Size as shipped, lump. Size as used, not determined. Duration of test, 40 hours.

Average electrical horsepower	200.2
Average B. T. U. gas, per cubic foot	147.1
Total coal fired, pounds	12,750

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 61.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.68	1.46	1.32
Developed at switch board	1.59	1.39	1.25
Per brake horsepower:			
Available for outside purposes	1.43	1.25	1.13
Developed at engine	1.35	1.18	1.06
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.83	1.59	1.44
Developed at switch board	1.73	1.51	1.36
Per brake horsepower:			
Available for outside purposes	1.56	1.35	1.22
Developed at engine	1.47	1.28	1.16

ANALYSES.

	Test 61.		Test 61.
Coal.		*Gas by volume.*	
Moisture	13.03	Carbon dioxide (CO_2)	10.6
Volatile matter	32.52	Carbon monoxide (CO)	18.3
Fixed carbon	46.19	Hydrogen (H_2)	13.9
Ash	8.26	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	54.1
Sulphur	1.68		100.0

COKING TEST.

Test 51, Indiana No. 11.

Size as shipped, lump. Size as used, finely crushed. Raw. Duration of test, 50 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,600
Breeze produced	do....	460
Coke produced	per cent..	55.00
Breeze produced	do....	3.83
Total percentage yield		58.83

Remarks.—Fine-fingered coke. Sulphur and ash high. Washing would probably reduce both and make a good grade of coke.

ANALYSES.

	Test 51.	
	Coal.	Coke.
Moisture	11.90	1.55
Volatile matter	32.50	1.66
Fixed carbon	46.94	84.09
Ash	8.66	12.70
Sulphur	1.53	1.34

KANSAS NO. 5.

Bituminous coal from mine No. 11, Southwestern Development Company, West Mineral, Kans., on the Missouri, Kansas and Texas Railway.

This sample was shipped in 1904 by M. R. Campbell, of the United States Geological Survey, and consisted of coal that had been passed over a five-eighths inch screen. During the Exposition period a steaming test was made on this coal [a], and at the beginning of 1905 producer-gas test No. 25 was run.

Mine samples were taken at widely separated points in the mine, the analyses of which are given under Nos. 1411 and 1413.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1411	1413	1567
Air-drying loss		3.20	4.30	2.30
Proximate.	Moisture	5.11	5.79	4.10
	Volatile matter	32.60	32.34	31.65
	Fixed carbon	53.39	49.32	53.71
	Ash	8.90	12.55	10.54
Ultimate.	Sulphur	4.34	3.84	3.77
	Hydrogen	.....	.....	5.10
	Carbon	.....	.....	70.25
	Nitrogen	.....	.....	1.06
	Oxygen	.....	.....	9.28
Calorific value determined:				
	Calories	7,181	.....	7,164
	British thermal units	12,926	.....	12,895

[a] See Bull. U. S. Geol. Survey No. 261, 1905, p. 81.

PRODUCER-GAS TEST:

Test 25, Kansas No. 5.

Size as shipped, over ¾ inch. Duration of test, 30 hours.

Average electrical horsepower	208.0
Average B. T. U. gas, per cubic foot	128.9
Total coal fired, pounds	8,650

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 25.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.46	1.40	1.25
Developed at switch board	1.39	1.33	1.19
Per brake horsepower:			
Available for outside purposes	1.24	1.19	1.06
Developed at engine	1.18	1.13	1.01
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.65	1.58	1.41
Developed at switch board	1.57	1.50	1.34
Per brake horsepower:			
Available for outside purposes	1.40	1.34	1.20
Developed at engine	1.33	1.27	1.14

ANALYSES.

	Test 25.		Test 25.
Coal.		*Gas by volume.*	
Moisture	4.23	Carbon dioxide (CO_2)	9.1
Volatile matter	31.49	Carbon monoxide (CO)	15.5
Fixed carbon	54.09	Hydrogen (H_2)	10.8
Ash	10.19	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	61.2
Sulphur	3.18	Oxygen (O_2)	.3
			100.0

KENTUCKY NO. 1.[a]

Bituminous coal from mine No. 2, Straight Creek Coal and Coke Company, Straight Creek, Bell County, Ky., on the Louisville and Nashville Railroad.

Two samples of coal were shipped from this mine under the supervision of Inspector J. W. Groves, as follows: Kentucky No. 1 B consisted of half 3-inch and 1-inch coal and half three-fourths inch coal, and was used in making producer-gas test No. 79 and coking test No. 76. Kentucky No. 1 C consisted of 1¼-inch slack coal, and the tests made on this sample were as follows: Coking test No. 71 and steaming tests Nos. 255, 263, and 265.

Two mine samples were taken from this mine for chemical analysis. No. 2350 was taken in room 99 off the main entry, 3,000 feet northeast of the drift mouth, and No. 2351 was taken in room 48 off the fourth north butt entry, 3,600 feet from the drift mouth.

[a] For tests made during 1904 see Bull. U. S. Geol. Survey No. 261, 1905, pp. 81, 126, 159.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2350	2351	2445
Air-drying loss		1.50	1.20	3.70
Proximate.	Moisture	3.42	3.25	5.21
	Volatile matter	35.90	36.08	33.47
	Fixed carbon	57.50	57.74	53.10
	Ash	3.18	2.93	8.22
Ultimate.	Sulphur	1.53	.91	1.12
	Hydrogen	.....	.....	5.28
	Carbon	.....	.....	73.08
	Nitrogen	.....	.....	1.67
	Oxygen	.....	.....	10.63
Calorific value determined:				
Calories		7,986	.....	7,341
British thermal units		14,375	.....	13,214

STEAMING TESTS.

Test 255, Kentucky No. 1 C.

Size as shipped, 1½-inch slack. Size as used, over 1 inch, 21.1 per cent; ½ inch to 1 inch, 26.7 per cent; ¼ inch to ½ inch, 20.0 per cent; under ¼ inch, 32.2 per cent. Duration of test, 8.13 hours. Kind of grate, plain.

Test 263, Kentucky No. 1 C.

Size as shipped, 1½-inch slack. Size as used, over 1 inch, 18.4 per cent; ½ inch to 1 inch, 22.2 per cent; ¼ inch to ½ inch, 21.2 per cent; under ¼ inch 38.2 per cent. Duration of test, 9.98 hours. Kind of grate, rocking

Test 265, Kentucky No. 1 C.

Size as shipped, 1½-inch slack. Size as used, over 1 inch 35.8 per cent; ½ inch to 1 inch, 24.4 per cent; ¼ inch to ½ inch, 17.0 per cent; under ¼ inch, 22.8 per cent. Duration of test, 6.83 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 255.	Test 263.	Test 265.
Heating value of coal.....B. T. U. per pound dry coal..	14,414	14,272	14,245
Force of draft:			
Under stack damper.....inch water..	0.44	0.47	0.46
Above fire.....do....	.12	.23	.13
Furnace temperature.....° F..	.....	.....	2,118
Dry coal used per square foot of grate surface per hour.....pounds..	17.73	16.02	14.43
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.30	2.82	2.76
Percentage of rated horsepower of boiler developed.....	92.7	78.9	77.2
Water apparently evaporated per pound of coal as fired.....pounds..	7.53	7.82	7.74
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	8.94	9.38	9.18
Per pound of dry coal.....do....	9.34	9.81	9.57
Per pound of combustible.....do....	10.08	10.83	10.44
Efficiency of boiler, including grate.....per cent..	62.58	66.38	64.88
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.16	3.01	3.08
Per electrical horsepower hour.....do....	3.91	3.72	3.80
Dry coal:			
Per indicated horsepower hour.....do....	3.03	2.88	2.95
Per electrical horsepower hour.....do....	3.74	3.56	3.65

ANALYSES.

	Test 255.	Test 263.	Test 265.		Test 255.	Test 263.	Test 265.
Proximate.				*Ultimate.*			
Moisture	4.26	4.45	4.14	Carbon[a]	79.78	78.98	78.82
Volatile matter	34.48	34.51	33.92	Hydrogen[a]	5.14	5.08	5.07
Fixed carbon	55.70	54.72	55.40	Oxygen[a]	6.54	6.49	6.47
Ash	5.56	6.32	6.54	Nitrogen[a]	1.82	1.80	1.80
	100.00	100.00	100.00	Sulphur	.91	1.03	1.02
Sulphur	.87	.98	.98	Ash	5.81	6.62	6.82
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 79, Kentucky No. 1 B.

Size as shipped, ¾ inch to 3 inches. Size as used, over 1 inch, 94 per cent; ½ inch to 1 inch, 5 per cent; ¼ inch to ½ inch, 1 per cent. Duration of test, 50 hours.

Average electrical horsepower	196.9
Average B. T. U. gas, per cubic foot	166.5
Total coal fired, pounds	13,050

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 79.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.40	1.37	1.32
Developed at switch board	1.33	1.29	1.25
Per brake horsepower:			
Available for outside purposes	1.19	1.16	1.12
Developed at engine	1.13	1.10	1.06
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.49	1.45	1.40
Developed at switch board	1.41	1.37	1.32
Per brake horsepower:			
Available for outside purposes	1.26	1.23	1.19
Developed at engine	1.19	1.16	1.12

ANALYSES.

	Test 79.		Test 79.
Coal.		*Gas by volume.*	
Moisture	2.61	Carbon dioxide (CO_2)	9.2
Volatile matter	36.29	Carbon monoxide (CO)	20.3
Fixed carbon	57.73	Hydrogen (H_2)	14.2
Ash	3.37	Methane (CH_4)	3.5
	100.00	Nitrogen (N_2)	52.8
Sulphur	.88		100.00

COKING TESTS.

Test 76, Kentucky No. 1 B.

Size as shipped, ¾ inch to 3 inches. Size as used, finely crushed. Raw. Duration of test, 51 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,026
Breeze produced	do ...	257
Coke produced	per cent..	66.88
Breeze produced	do....	2.14
Total percentage yield		69.02

Remarks.—Fine-fingered coke. Light gray, silvery, somewhat brittle. High yield due to deposited carbon.

Test 71, Kentucky No. 1 C.

Size as shipped, 1¼ inches slack. Size as used, finely crushed. Raw. Duration of test, 64 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,319
Breeze produced	do....	355
Coke produced	per cent..	60.99
Breeze produced	do....	2.96
Total percentage yield		63.95

Remarks.—Light gray, with some little deposited carbon. Good coke. Washing would probably reduce ash and improve quality of coke.

ANALYSES.

	Test 76.		Test 71.	
	Coal.	Coke.	Coal.	Coke.
Moisture	3.55	0.93	5.64	1.32
Volatile matter	35.49	1.25	32.41	1.53
Fixed carbon	55.88	91.40	52.77	84.68
Ash	5.08	6.42	9.18	12.47
Sulphur	1.17	1.05	1.11	.96

KENTUCKY NO. 5.

Bituminous coal from Gilliam's Rockhouse prospect, Interstate Investment Company, on Big Black Mountain, Harlan County, Ky., 15 miles from the Louisville and Nashville Railroad.

This was a sample of run-of-mine coal that was mined from a small prospect hole on the outcrop and hauled in wagons to the railroad under the supervision of Inspector J. S. Burrows. The following tests were made on this sample: Coking test No. 75, steaming tests nos. 276 and 277, and producer-gas test No. 81.

Three samples for chemical analysis were obtained by the inspector from this deposit of coal, which is locally known as the "High Splint bed," as follows: No. 2271 was taken from a prospect hole 1 mile south of Gilliam's Rockhouse; No. 2272 from the face of Gilliam's Rockhouse prospect hole, 25 feet from the outcrop; and No. 2270 was selected from a quantity of weathered coal lying in the ravine below the point from which No. 2271 was taken.

CHEMICAL ANALYSES.

		Mine samples.			Car sample.
Laboratory number		2271	2272	2270	2528
Air-drying loss		2.10	2.50	2.20	2.80
Proximate.	Moisture	4.45	4.72	4.32	4.36
	Volatile matter	36.27	35.74	36.04	35.02
	Fixed carbon	56.05	57.06	57.36	56.92
	Ash	3.23	2.48	2.28	3.70
Ultimate.	Sulphur	.54	.54	.48	.67
	Hydrogen				5.16
	Carbon				77.44
	Nitrogen				1.57
	Oxygen				11.46
Calorific value determined:					
	Calories			7,845	7,735
	British thermal units			14,121	13,923

STEAMING TESTS.

Test 276, Kentucky No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 67.5 per cent; ½ inch to 1 inch, 11.6 per cent; ¼ inch to ½ inch, 7.4 per cent; under ¼ inch, 13.5 per cent. Duration of test, 9.78 hours. Kind of grate, rocking.

Test 277, Kentucky No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 54.4 per cent; ½ inch to 1 inch, 14.7 per cent; ¼ inch to ½ inch, 11.8 per cent; under ¼ inch, 19.1 per cent. Duration of test, 9.30 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 276.	Test 277.
Heating value of coal.....B. T. U. per pound dry coal..	14,571	14,510
Force of draft:		
Under stack damper.....inch water..	0.45	0.36
Above fire.....do....	.15	.08
Furnace temperature.....°F..	2,799	.....
Dry coal used per square foot of grate surface per hour.....pounds..	21.98	15.39
Equivalent water evaporated per square foot of water-heating surface per hour, pounds.....	3.98	3.20
Percentage of rated horsepower of boiler developed.....	111.6	89.7
Water apparently evaporated per pound of coal as fired.....pounds..	8.01	8.28
Water evaporated from and at 212 °F.:		
Per pound of coal as fired.....do....	9.63	9.86
Per pound of dry coal.....do....	10.10	10.42
Per pound of combustible.....do....	10.62	11.13
Efficiency of boiler, including grate.....per cent..	66.94	69.35
Coal as fired:		
Per indicated horsepower hour.....pounds..	2.94	2.87
Per electrical horsepower hour.....do....	3.63	3.54
Dry coal:		
Per indicated horsepower hour.....do....	2.80	2.71
Per electrical horsepower hour.....do....	3.46	3.35

ANALYSES.

	Test 276.	Test 277.		Test 276.	Test 277.
Proximate.			*Ultimate.*		
Moisture	4.72	5.40	Carbon[a]	81.08	80.72
Volatile matter	34.96	34.57	Hydrogen[a]	4.90	4.87
Fixed carbon	56.57	56.06	Oxygen[a]	7.93	7.90
Ash	3.75	3.97	Nitrogen[a]	1.65	1.64
	100.00	100.00	Sulphur	.50	.67
Sulphur	.48	.63	Ash	3.94	4.20
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 81, Kentucky No. 5.

Size as shipped, run of mine. Size as used, over 1 inch, 71 per cent; ½ inch to 1 inch, 10 per cent; ¼ inch to ½ inch, 8 per cent; under ¼ inch, 11 per cent. Duration of test, 50 hours.

Average electrical horsepower	198.2
Average B. T. U. gas, per cubic foot	163.2
Total coal fired.....pounds..	12,900

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 81.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.38	1.33	1.28
Developed at switch board	1.30	1.25	1.20
Per brake horsepower:			
Available for outside purposes	1.18	1.13	1.08
Developed at engine	1.11	1.07	1.02
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.47	1.42	1.36
Developed at switch board	1.39	1.33	1.28
Per brake horsepower:			
Available for outside purposes	1.25	1.20	1.15
Developed at engine	1.18	1.13	1.08

ANALYSES.

	Test 81.		Test 81.
Coal.		*Gas by volume.*	
Moisture	3.75	Carbon dioxide (CO_2)	8.8
Volatile matter	36.05	Carbon monoxide (CO)	21.0
Fixed carbon	56.17	Hydrogen (H_2)	14.9
Ash	4.03	Methane (CH_4)	3.4
	100.00	Nitrogen (N_2)	51.9
Sulphur	0.47		100.0

COKING TEST.

Test 75, Kentucky No. 5.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 49 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,993
Breeze produced	do....	256
Coke produced	per cent..	66.61
Breeze produced	do....	2.13
Total percentage yield		68.74

Remarks.—Light gray and silvery. Fine heavy coke. High yield due to deposited carbon.

ANALYSES.

	Test 75.	
	Coal.	Coke.
Moisture	4.67	0.30
Volatile matter	35.33	1.21
Fixed carbon	56.30	93.26
Ash	3.70	5.23
Sulphur	.45	.41

KENTUCKY NO. 6.

Bituminous coal furnished by Justus Collins, of Charleston, W. Va., from Miller Creek country bank, 5 miles southeast of Paintsville, Johnson County, Ky., 7 miles from the Chesapeake and Ohio Railway.

This sample consisted of run-of-mine coal, which was loaded in wagons and hauled to the railroad under the supervision of Inspector W. J. Von Borries. It was used in making coking tests Nos. 86 and 90, steaming tests Nos. 270 and 271, and producer-gas test No. 85.

Two mine samples were taken from this country bank for chemical analysis. No. 2405 was from the first right entry, 100 feet west of the drift mouth; No. 2406 was taken on the main entry, 140 feet west of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2405	2406	2592
Air-drying loss		4.50	4.20	2.20
Proximate.	Moisture	6.95	6.52	5.12
	Volatile matter	35.03	34.42	36.49
	Fixed carbon	55.99	56.80	55.63
	Ash	2.03	2.26	2.76
	Sulphur	.48	.45	.57
Ultimate.	Hydrogen			5.47
	Carbon			77.20
	Nitrogen			1.45
	Oxygen			12.55
Calorific value determined:				
	Calories	7,604		7,635
	British thermal units	13,687		13,743

STEAMING TESTS.

Test 270, Kentucky No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 62.6 per cent; ½ inch to 1 inch, 16.5 per cent; ¼ inch to ½ inch, 9.4 per cent; under ¼ inch, 11.5 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 271, Kentucky No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 62.2 per cent; ½ inch to 1 inch, 14.1 per cent; ¼ inch to ½ inch, 7.6 per cent; under ¼ inch, 16.1 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 270.	Test 271.
Heating value of coal	B. T. U. per pound dry coal	14,445	14,512
Force of draft:			
Under stack damper	inch water	0.37	0.35
Above fire	do	.08	.05
Furnace temperature	°F.	2,412	2,426
Dry coal used per square foot of grate surface per hour	pounds	16.03	15.86
Equivalent water evaporated per square foot of water-heating surface per hour	pounds	3.19	3.12
Percentage of rated horsepower of boiler developed		89.4	87.6
Water apparently evaporated per pound of coal as fired	pounds	7.91	7.83
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	9.50	9.37
Per pound of dry coal	do	9.96	9.86
Per pound of combustible	do	10.42	10.33
Efficiency of boiler, including grate	per cent	66.59	65.61

MISCELLANEOUS ITEMS—continued.

		Test 270.	Test 271.
Coal as fired:			
Per indicated horsepower hour	pounds..	2.98	3.02
Per electrical horsepower hour	do....	3.68	3.73
Dry coal:			
Per indicated horsepower hour	do....	2.84	2.87
Per electrical horsepower hour	do....	3.51	3.54

ANALYSES.

	Test 270.	Test 271.		Test 270.	Test 271.
Proximate.			*Ultimate.*		
Moisture	4.69	5.01	Carbon[a]	81.18	81.53
Volatile matter	35.63	36.23	Hydrogen[a]	5.16	5.19
Fixed carbon	56.56	56.09	Oxygen[a]	8.41	8.43
Ash	3.12	2.67	Nitrogen[a]	1.52	1.53
	100.00	100.00	Sulphur	.46	.51
Sulphur	.44	.48	Ash	3.27	2.81
				100.09	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 85, Kentucky No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 73 per cent; ½ inch to 1 inch, 11 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 11 per cent. Duration of test, 50 hours.

Average electrical horsepower	199.5
Average B. T. U. gas, per cubic foot	176.0
Total coal fired	pounds.. 12,600

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 85.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.34	1.28	1.24
Developed at switch board	1.26	1.21	1.16
Per brake horsepower:			
Available for outside purposes	1.14	1.09	1.05
Developed at engine	1.07	1.03	.99
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.42	1.35	1.30
Developed at switch board	1.33	1.27	1.23
Per brake horsepower:			
Available for outside purposes	1.20	1.15	1.11
Developed at engine	1.13	1.08	1.04

ANALYSES.

	Test 85.		Test 85.
Coal.		*Gas by volume.*	
Moisture	4.49	Carbon dioxide (CO_2)	7.7
Volatile matter	36.82	Carbon monoxide (CO)	23.6
Fixed carbon	55.28	Hydrogen (H_2)	16.6
Ash	3.41	Methane (CH_4)	2.9
	100.00	Nitrogen (N_2)	49.2
Sulphur	.51		100.0

COKING TESTS.

Test 86, Kentucky No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 56 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,780
Breeze produced	do....	587
Coke produced	per cent..	56.50
Breeze produced	do....	4.89
Total percentage yield		61.39

Remarks.—Light gray and silvery, with ¼-inch black butts. Fine-fingered coke. Could not burn coal to coke without butts. Very hard to burn.

Test 90, Kentucky No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 55 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,659
Breeze produced	do....	447
Coke produced	per cent..	55.49
Breeze produced	do....	3.73
Total percentage yield		59.22

Remarks.—Light gray and silvery. One-half inch black butts could not be remedied, though this test is better than No. 86. Fine-fingered coke.

ANALYSES.

	Test 86.		Test 90.	
	Coal.	Coke.	Coal.	Coke.
Moisture	5.21	2.81	5.42	1.64
Volatile matter	36.82	1.27	36.82	1.69
Fixed carbon	55.62	91.93	55.30	92.26
Ash	2.35	3.99	2.46	4.41
Sulphur	.51	.40	.48	.37

KENTUCKY NO. 7.

Bituminous coal from Central mine, Central Coal and Iron Company, Central City, Muhlenberg County, Ky., on the Illinois Central Railroad.

This sample was shipped under the supervision of Inspector J. W. Groves, and consisted of "standard lump" coal over 1½-inch bar screen. The sample was used for making coking test No. 85, steaming tests Nos. 278 and 279, and producer-gas test No. 84.

Mine samples taken for chemical analysis were as follows: No. 2453 was taken from the face of room 43 off the fourteenth north entry, 1¼ miles northeast of the shaft; No. 2454 was taken from room 9 off the fourteenth south entry, 1¼ miles south of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2453	2454	2595
Air-drying loss		5.70	3.90	3.00
Proximate.	Moisture	8.76	8.75	8.47
	Volatile matter	35.02	34.00	35.24
	Fixed carbon	46.80	46.48	46.81
	Ash	9.42	10.77	9.48
Ultimate.	Sulphur	4.07	3.69	3.60
	Hydrogen			5.24
	Carbon			65.77
	Nitrogen			1.29
	Oxygen			14.03
Calorific value determined:				
	Calories	6,647		6,650
	British thermal units	11,965		11,986

STEAMING TESTS.

Test 278, Kentucky No. 7.

Size as shipped, standard lump. Size as used, over 1 inch, 26.8 per cent; ½ inch to 1 inch, 24.7 per cent; ¼ inch to ½ inch, 20.6 per cent; under ¼ inch, 27.9 per cent. Duration of test, 9.60 hours. Kind of grate, rocking.

Test 279, Kentucky No. 7.

Size as shipped, standard lump. Size as used, over 1 inch, 36.1 per cent; ½ inch to 1 inch, 24.1 per cent; ¼ inch to ½ inch, 7.4 per cent; under ¼ inch, 32.4 per cent. Duration of test, 9.22 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 278.	Test 279.
Heating value of coal	B. T. U. per pound dry coal	12,564	12,505
Force of draft:			
Under stack damper	inch water	0.37	0.41
Above fire	do	.12	.14
Furnace temperature	°F		1,983
Dry coal used per square foot of grate surface per hour	pounds	16.95	14.60
Equivalent water evaporated per square foot of water-heating surface per hour	pounds	2.69	2.44
Percentage of rated horsepower of boiler developed		75.3	68.4
Water apparently evaporated per pound of coal as fired	pounds	6.67	6.45
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	8.01	7.63
Per pound of dry coal	do	8.84	8.38
Per pound of combustible	do	10.44	10.05
Efficiency of boiler, including grate	per cent	67.95	64.71
Coal as fired:			
Per indicated horsepower hour	pounds	3.53	3.71
Per electrical horsepower hour	do	4.36	4.58
Dry coal:			
Per indicated horsepower hour	do	3.20	3.37
Per electrical horsepower hour	do	3.95	4.17

ANALYSES.

	Test 278.	Test 279.		Test 278.	Test 279.
Proximate.			*Ultimate.*		
Moisture	9.39	9.01	Carbon[a]	68.66	68.36
Volatile matter	33.27	33.72	Hydrogen[a]	4.49	4.47
Fixed carbon	45.49	44.92	Oxygen[a]	7.42	7.39
Ash	11.85	12.35	Nitrogen[a]	1.34	1.33
	100.00	100.00	Sulphur	5.01	4.88
Sulphur	4.54	4.44	Ash	13.08	13.57
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 84, Kentucky No. 7.

Size as shipped, "standard lump." Size as used, over 1 inch, 73 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 6 per cent; under ¼ inch, 7 per cent. Duration of test, 50 hours.

Average electrical horsepower	195.5
Average B. T. U. gas, per cubic foot	153.7
Total coal fired, pounds	15,300

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 84.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.66	1.52	1.36
Developed at switch board	1.57	1.43	1.28
Per brake horsepower:			
Available for outside purposes	1.41	1.29	1.16
Developed at engine	1.33	1.22	1.09
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.75	1.60	1.44
Developed at switch board	1.65	1.51	1.35
Per brake horsepower:			
Available for outside purposes	1.49	1.36	1.22
Developed at engine	1.40	1.29	1.15

ANALYSES.

	Test 84.		Test 84.
Coal.		*Gas by volume.*	
Moisture	8.47	Carbon dioxide (CO_2)	9.6
Volatile matter	35.24	Carbon monoxide (CO)	19.2
Fixed carbon	46.81	Hydrogen (H_2)	13.1
Ash	9.48	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	55.0
Sulphur	3.60		100.0

COKING TEST.

Test 85, Kentucky No. 7.

Size as shipped, "standard lump." Size as used, finely crushed. Raw. Duration of test, 40 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,865
Breeze produced	do....	342
Coke produced	per cent..	57.21
Breeze produced	do....	2.85
Total percentage yield		60.06

Remarks. Light gray silvery. Good weight coke. Contains large amount of hard clinker on top and through cracks. Ash and sulphur both high, might be improved by washing.

ANALYSES.

	Test 85.	
	Coal.	Coke.
Moisture	8.82	0.23
Volatile matter	35.03	2.16
Fixed carbon	46.78	82.97
Ash	9.37	14.64
Sulphur	3.56	3.16

MARYLAND NO. 1.

Bituminous coal from Washington No. 3 mine, Piedmont and Georges Creek Coal Company, 2 miles north of Westernport, Garrett County, Md., on the Cumberland and Pennsylvania Railroad.

This sample of coal was loaded under the supervision of Inspector J. W. Groves, and consisted of run of mine. It was used in making washing test No. 130, coking tests Nos. 50, 54, and 58, steaming test No. 222, and steaming tests on washed coal Nos. 231 and 232.

Two mine samples were taken for chemical analysis, as follows: No. 2018 was cut from the face of room 2, sixth right entry, 1,600 feet west of the drift mouth; No. 2019 was cut from the face of room 3, off the eighth left entry, 1,900 feet southwest of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2018	2019	2274
Air-drying loss		1.80	2.50	1.40
Proximate.	Moisture	2.47	3.45	2.33
	Volatile matter	14.03	13.73	16.11
	Fixed carbon	73.95	71.97	68.43
	Ash	9.55	10.85	13.13
Ultimate.	Sulphur	1.23	1.60	1.49
	Hydrogen			3.99
	Carbon			75.21
	Nitrogen			1.29
	Oxygen			4.89
Calorific value determined:				
	Calories	7,696		7,364
	British thermal units	13,853		13,255

STEAMING TESTS.

Test 222, Maryland No. 1.

Size as shipped, run of mine. Size as used, over 1 inch, 5.2 per cent; ½ inch to 1 inch, 6.9 per cent; ¼ inch to ½ inch, 14.5 per cent; under ¼ inch 73.4 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 231, Maryland No. 1, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 17.2 per cent; ½ inch to 1 inch, 21.2 per cent; ¼ inch to ½ inch, 22.2 per cent; under ¼ inch, 39.4 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 232, Maryland No. 1, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 15.7 per cent; ½ inch to 1 inch, 14.7 per cent; ¼ inch to ½ inch, 17.3 per cent; under ¼ inch, 52.3 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 222.	Test 231.	Test 232.
Heating value of coal .....B. T. U. per pound dry coal..	13,680	13,946	14,033
Force of draft:			
Under stack damper.....inch water..	0.49	0.46	0.41
Above fire.....do....	.16	.11	.12
Furnace temperature.....°F..	2,129	2,398	2,350
Dry coal used per square foot of grate surface per hour.....pounds..	15.81	19.67	19.42
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.86	3.42	3.32
Percentage of rated horsepower of boiler developed.....	80.1	95.9	93.2
Water apparently evaporated per pound of coal as fired.....pounds..	7.59	7.86	7.75
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	8.90	9.34	9.22
Per pound of dry coal.....do....	9.06	9.70	9.55
Per pound of combustible.....do....	10.60	11.14	10.98
Efficiency of boiler, including grate.....per cent..	63.96	67.17	65.72
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.18	3.03	3.07
Per electrical horsepower hour.....do....	3.92	3.74	3.79
Dry coal:			
Per indicated horsepower hour.....do....	3.12	2.91	2.96
Per electrical horsepower hour.....do....	3.85	3.60	3.66

ANALYSES.

	Test 222.	Test 231.	Test 232.		Test 222.	Test 231.	Test 232.
Proximate.				*Ultimate.*			
Moisture.....	1.84	3.70	3.43	Carbon[a].....	77.60	79.52	80.02
Volatile matter.....	14.03	13.96	14.08	Hydrogen[a].....	3.85	3.95	3.97
Fixed carbon.....	71.61	71.63	72.36	Oxygen[a].....	2.90	2.97	3.01
Ash.....	12.52	10.71	10.13	Nitrogen[a].....	1.34	1.36	1.38
	100.00	100.00	100.00	Sulphur.....	1.55	1.08	1.14
Sulphur.....	1.52	1.04	1.10	Ash.....	12.76	11.12	10.48
					100.00	100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 130, Maryland No. 1.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	45,500
Washed coal	do....	37,450
Refuse	do....	8,050

ANALYSES.

	Test 130.	
	Raw coal.	Washed coal.
Moisture	2.33	3.67
Volatile matter	16.11	.....
Fixed carbon	68.43	.....
Ash	13.13	10.61
Sulphur	1.49	1.09

COKING TESTS.

Test 50, Maryland No. 1.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 36 hours.

Remarks.—No coke produced.

Test 54, Maryland No. 1, washed.

Size as shipped, run of mine. Size as used not crushed. Duration of test, 48 hours.

Remarks.—No coke produced.

Test 58, Maryland No. 1, washed.

Size as shipped, run of mine. Size as used, finely crushed. 10 per cent pitch added. Duration of test, 54 hours.

Coal charged	pounds..	8,000
Coke produced	do....	4,650
Breeze produced	do....	565
Coke produced	per cent..	58.13
Breeze produced	do....	7.06
Total percentage yield		65.19

Remarks.—Dull-gray color. Very poor coke. Soft and dense. Breaks in large and small chunks.

ANALYSES.

	Test 58.	
	Coal.	Coke.
Moisture	4.35	0.27
Volatile matter	17.81	.88
Fixed carbon	68.86	87.47
Ash	8.98	11.38
Sulphur	1.09	.95

MASSACHUSETTS NO. 1.

Peat briquettes from bog near Halifax, Plymouth County, Mass. They were furnished by Prof. C. L. Norton, of the Massachusetts Institute of Technology, Boston, Mass., and shipped under the supervision of J. S. Burrows.

This sample consisted of a small amount (less than 5 tons) of peat which had been macerated and pressed into bricks and then dried, and it was impossible to run a test of sufficient length to eliminate the factor of uncertainty. It was demonstrated, however, that a satisfactory gas could be obtained, and no trouble was experienced in manipulating the fuel bed or in maintaining the load, but owing to the small supply of peat it was necessary to make the foundation of the fuel bed out of another fuel—Illinois coal. Considering this fact and that the amount of peat furnished made it possible to conduct a test of only nine hours' duration, it is possible that the results as given below are somewhat erroneous.

The figures are given, however, for what they are worth, as they furnish an approximate idea of the possibilities of peat fuel in the gas producer, although they can not be regarded as official results. It is impossible to tell exactly what portion of the gas was due to the Illinois coal and what portion to the peat alone.

The results of the tests of the Massachusetts peat were as follows:

PRODUCER-GAS TEST.

Test 97. Massachusetts No. 1.

Average electrical horsepower	200.0
Average B. T. U. gas, per cubic foot	166.6
Total peat fired.....pounds..	6,490

PEAT CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 97.		
	Peat as fired.	Dry peat.	Combustible.
Per electrical horsepower:			
Available for outside purposes	3.77	1.89	1.44
Developed at switch board	3.60	1.81	1.38
Per brake horsepower:			
Available for outside purposes	3.20	1.61	1.22
Developed at engine	3.06	1.54	1.17

ANALYSES.

	Test 97.		Test 97.
Peat.		*Gas by volume.*	
Moisture	49.80	Carbon dioxide (CO_2)	10.5
Volatile matter	27.27	Carbon monoxide (CO)	22.5
Fixed carbon	10.88	Hydrogen (H_2)	13.9
Ash	12.05	Methane (CH_4)	2.1
	100.00	Nitrogen (N_2)	51.0
Sulphur	0.34		100.0

In connection with this test of a small quantity of Massachusetts peat it is deemed advisable to refer briefly to a more elaborate test of peat bricks obtained from Florida, the results of which test have been obtained in time to be mentioned here, although the test was run subsequent to the date covered by the body of the report. In the producer-gas test of the Florida peat the producer was maintained in operation for fifty hours, and no difficulty whatever was experienced either in maintaining the load or in handling the fuel bed. The peat was furnished by the Orlando Water and Light Company and was secured from a bog near the city of Orlando, Orange County, Fla.

In starting the producer test the fuel bed was built up entirely of the Florida peat, and the usual preliminary run was conducted before the official test began. The total amount of peat consumed in the producer in the fifty-hour run was 29,250 pounds, or 585 pounds per hour. The average calorific value of the gas produced was 175 British thermal units per cubic foot. During the entire run the average electrical horsepower developed at the switch board was 205. The amount of peat used per electrical horsepower per hour available for outside purposes, including the estimated quantity required for the generation of the steam used in the operation of the producer, was 3.16 pounds, while 2.69 pounds were required per brake horsepower hour at the gas engine, available for outside purposes.

It should be stated that the peat bricks had been dried and that the moisture content of those used averaged 21 per cent. The gas was particularly rich in hydrogen, running 18.5 per cent, and comparatively low in nitrogen (45.5 per cent).

As there was a small supply of peat bricks left after the completion of the gas-producer tests, a short run of a little over four hours was made in the boilers. This was not sufficiently long to make any definite conclusions possible, but the results obtained were exceedingly satisfactory so far as they went. No difficulty was encountered in keeping the boiler up to its rated capacity, and, in fact, during the four hours' run the percentage of rated horsepower of the boiler developed was 113.2. The amount of peat burned per indicated horsepower hour at the steam engine was 5.66 pounds, and per electrical horsepower hour at the switch board was 6.98 pounds. The calorific value of the peat as used was 10,082 British thermal units per pound. The principal difficulty in the utilization of peat under boilers appears to be the frequency with which it is necessary to fire. On account of the lightness of the material and also on account of its rapid combustion the fireman was kept at work almost constantly during the test.

NORTH DAKOTA NO. 1 B.

Brown lignite from Lehigh mine, Consolidated Coal Company, Lehigh, Stark County N. Dak., on the Northern Pacific Railway.

This sample consisted of run of mine, and was shipped under the supervision of M. R. Campbell, of the United States Geological Survey. Producer-gas test No. 68 was run on this sample.[a]

Two mine samples (Nos. 1971 and 1972) were taken at widely separated points in the mine for chemical analysis.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1971	1972	2289
Air-drying loss		35.60	33.90	10.40
Proximate.	Moisture	42.06	42.81	32.64
	Volatile matter	24.55	26.84	29.19
	Fixed carbon	25.73	23.93	26.75
	Ash	7.66	6.42	11.42
Ultimate.	Sulphur	1.13	.96	3.54
	Hydrogen	.....	.....	6.15
	Carbon	.....	.....	39.53
	Nitrogen	.....	.....	.49
	Oxygen	.....	.....	38.87
Calorific value determined:				
	Calories	3,421	.....	3,872
	British thermal units	6,158	.....	6,970

[a] For tests of sample furnished in 1904, see Bull. U. S. Geol. Survey No. 261, 1905, pp. 82, 162.

PRODUCER-GAS TEST.

Test 68, North Dakota No. 1 B.

Size as shipped, run of mine. Size as used, over 1 inch, 79 per cent; ½ inch to 1 inch, 9 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 7 per cent. Duration of test, 49 hours.

Average electrical horsepower	198.4
Average B. T. U. gas, per cubic foot	160.6
Total coal fired, pounds	26,000

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 68.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	2.88	1.94	1.61
Developed at switch board	2.67	1.80	1.50
Per brake horsepower:			
Available for outside purposes	2.45	1.65	1.37
Developed at engine	2.27	1.53	1.27
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	3.04	2.05	1.70
Developed at switch board	2.82	1.90	1.58
Per brake horsepower:			
Available for outside purposes	2.58	1.74	1.45
Developed at engine	2.40	1.61	1.34

ANALYSES.

	Test 68.		Test 68.
Coal.		*Gas by volume.*	
Moisture	32.64	Carbon dioxide (CO_2)	8.2
Volatile matter	29.19	Carbon monoxide (CO)	25.2
Fixed carbon	26.75	Hydrogen (H_2)	15.3
Ash	11.42	Methane (CH_4)	2.6
	100.00	Nitrogen (N_2)	48.7
Sulphur	3.54		100.0

NORTH DAKOTA NO. 2 B.

Brown lignite from mouth of Cedar Coulee, 4 miles southeast of Williston, Williams County, N. Dak., furnished by the engineers of the United States Reclamation Service.

This sample consisted of run-of-mine coal, and was used in making producer-gas test No. 72.[a]

Mine sample No. 1730 was taken in this mine for chemical analysis.

[a] For tests of sample shipped during 1904, see Bull. U. S. Geol. Survey No. 261, 1905, p. 104.

CHEMICAL ANALYSES.

		Mine sample.	Car sample.
Laboratory number		1730	2365
Air-drying loss		33.10	17.30
Proximate.	Moisture	41.13	36.13
	Volatile matter	27.17	29.28
	Fixed carbon	26.34	29.55
	Ash	5.36	5.04
Ultimate.	Sulphur	.72	.59
	Hydrogen		6.60
	Carbon		42.00
	Nitrogen		.73
	Oxygen		45.04
Calorific value determined:			
	Calories	3,603	4,070
	British thermal units	6,485	7,326

PRODUCER-GAS TEST.

Test 72, North Dakota No. 2 B.

Size as shipped, run of mine. Size as used, over 1 inch, 82 per cent; ½ inch to 1 inch, 7 per cent; ¼ inch to ½ inch, 5 per cent; under ¼ inch, 6 per cent. Duration of test, 50 hours.

Average electrical horsepower	195.5
Average B. T. U. gas, per cubic foot	164.1
Total coal fired, pounds	26,000

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 72.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	2.80	1.79	1.65
Developed at switch board	2.66	1.70	1.57
Per brake horsepower:			
Available for outside purposes	2.38	1.52	1.40
Developed at engine	2.26	1.44	1.33
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.97	1.90	1.75
Developed at switch board	2.83	1.80	1.66
Per brake horsepower:			
Available for outside purposes	2.53	1.61	1.49
Developed at engine	2.40	1.53	1.41

ANALYSES.

	Test 72.		Test 72.
Coal.		*Gas by volume.*	
Moisture	36.13	Carbon dioxide (CO_2)	9.3
Volatile matter	29.28	Carbon monoxide (CO)	22.9
Fixed carbon	29.55	Hydrogen (H_2)	15.6
Ash	5.04	Methane (CH_4)	2.7
	100.00	Nitrogen (N_2)	49.5
Sulphur	.59		100.0

NORTH DAKOTA NO. 3.

Brown lignite from Wilton mine, Washburn Lignite Coal Company, 1 mile east of Wilton, McLean County, N. Dak., on the Minneapolis, St. Paul and Sault Ste. Marie Railway.

This sample was made up of lump lignite and was shipped under the supervision of M. R. Campbell, of the United States Geological Survey. It was used in making steaming test No. 206 and producer-gas test No. 67.

Mine samples Nos. 1935 and 1938 were taken at widely separated points in the mine for chemical analysis.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1935	1938	2243
Air-drying loss		32.30	33.50	12.70
Proximate.	Moisture	40.53	41.88	35.96
	Volatile matter	27.05	26.11	31.92
	Fixed carbon	27.37	26.73	24.37
	Ash	5.05	5.28	7.75
Ultimate.	Sulphur	.76	.96	1.15
	Hydrogen	.....	.....	6.54
	Carbon	.....	.....	41.43
	Nitrogen	.....	.....	1.21
	Oxygen	.....	.....	41.92
Calorific value determined:				
	Calories	3,691	.....	3,927
	British thermal units	6,644	.....	7,069

STEAMING TEST.

Test 206, North Dakota No. 3.

Size as shipped, lump. Size as used, average diameter, three inches, 76.5 per cent; ½ inch to 1 inch, 10.6 per cent; ¼ inch to ½ inch, 4.9 per cent; under ¼ inch, 8 per cent. Duration of test, 5.72 hours. Kind of gate, rocking.

MISCELLANEOUS ITEMS.

	Test 206.
Heating value of coal, B. T. U. per pound dry coal	11,036
Force of draft:	
Under stack damper, inch water	0.65
Above fire, do	a.10
Furnace temperature, °F.	2,093
Dry coal used per square foot of grate surface per hour, pounds	27.99
Equivalent water evaporated per square foot of water-heating surface per hour, do	3.24
Percentage of rated horsepower of boiler developed	90.7
Water apparently evaporated per pound of coal as fired, pounds	3.52
Water evaporated from and at 212° F.:	
Per pound of coal as fired, do	4.13
Per pound of dry coal, do	6.45
Per pound of combustible, do	7.47
Efficiency of boiler, including grate, per cent	56.44
Coal as fired:	
Per indicated horsepower hour, pounds	6.85
Per electrical horsepower hour, do	8.46
Dry coal:	
Per indicated horsepower hour, do	4.38
Per electrical horsepower hour, do	5.41

a Forced draft.

ANALYSES.

	Test 206.		Test 206.
Proximate.		*Ultimate.*	
Moisture	35.96	Carbon[a]	64.69
Volatile matter	31.92	Hydrogen[a]	3.97
Fixed carbon	24.37	Oxygen[a]	15.55
Ash	7.75	Nitrogen[a]	1.89
	100.00	Sulphur	1.80
Sulphur	1.15	Ash	12.10
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 67, North Dakota No. 3.

Size as shipped, lump. Size as used, over 1 inch, 85 per cent; ½ inch to 1 inch, 6 per cent; ¼ inch to ½ inch, 3 per cent; under ¼ inch, 6 per cent. Duration of test 50 hours.

Average electrical horsepower	195.5
Average B. T. U. gas, per cubic foot	158.9
Total coal fired, pounds	30,250

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 67.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	3.27	2.10	1.89
Developed at switch board	3.10	1.99	1.79
Per brake horsepower:			
Available for outside purposes	2.78	1.78	1.61
Developed at engine	2.63	1.69	1.52
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	3.42	2.20	1.98
Developed at switch board	3.24	2.08	1.87
Per brake horsepower:			
Available for outside purposes	2.92	1.87	1.68
Developed at engine	2.75	1.77	1.59

ANALYSES.

	Test 67.		Test 67.
Coal.		*Gas by volume.*	
Moisture	35.78	Carbon dioxide (CO_2)	9.0
Volatile matter	28.76	Carbon monoxide (CO)	23.2
Fixed carbon	29.01	Hydrogen (H_2)	15.5
Ash	6.45	Methane (CH_4)	2.7
	100.00	Nitrogen (N_2)	49.6
Sulphur	.90		100.0

OHIO NO. 1.

Bituminous coal from mine No. 10, Superior Coal Company, 9 miles southeast of Wellston, Jackson County, Ohio, on the Baltimore and Ohio Railroad.

This sample consisted of run-of-mine coal from No. 4 bed and was loaded under the supervision of Inspector J. W. Groves. Both No. 4 and No. 5 seams are worked in this mine.[a]

The following tests were made on this coal: Washing test No. 119, coking test No. 24, steaming test No. 191, and steaming test on washed coal No. 192.

Two mine samples were taken in this mine for chemical analysis. No. 1896 was cut from a point 1,400 feet southwest of the entrance to the mine, in room 16, off the fourth right entry. No. 1897 was taken at a point 1,400 feet northeast of the entrance to the mine, at the face of room 17, off the fourth right entry.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1896	1897	2071
Air-drying loss		4.90	3.70	4.90
Proximate.	Moisture	8.45	7.50	7.71
	Volatile matter	41.27	39.25	38.32
	Fixed carbon	43.55	42.74	42.02
	Ash	6.73	10.51	11.95
Ultimate.	Sulphur	3.10	5.44	4.61
	Hydrogen	.....	.....	5.41
	Carbon	.....	.....	62.49
	Nitrogen	.....	.....	1.11
	Oxygen	.....	.....	14.43
Calorific value determined:				
	Calories	6,805	.....	6,397
	British thermal units	12,249	.....	11,515

STEAMING TESTS.

Test 191, Ohio No. 1.

Size as shipped, run of mine. Size as used, over 1 inch, 19.3 per cent; ½ inch to 1 inch, 22.4 per cent; ¼ inch to ½ inch, 19.4 per cent; under ¼ inch, 38.9 per cent. Duration of test, 9.92 hours. Kind of grate, rocking.

Test 192, Ohio No. 1, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 37.9 per cent; ½ inch to 1 inch, 27.8 per cent; ¼ inch to ½ inch, 18.1 per cent; under ¼ inch, 16.2 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

		Test 191.	Test 192.
Heating value of coal	B. T. U. per pound dry coal	11,704	13,041
Force of draft:			
Under stack damper	inch water	0.52	0.53
Above fire	do	.15	.18
Furnace temperature	°F.	2,194	2,384
Dry coal used per square foot of grate surface per hour	pounds	20.66	21.57
Equivalent water evaporated per square foot of water-heating surface per hour, pounds		2.98	3.21
Percentage of rated horsepower of boiler developed		83.6	90.1
Water apparently evaporated per pound of coal as fired	pounds	6.36	6.48

[a] For tests of No. 5 coal see Ohio No. 2 (p. 142).

MISCELLANEOUS ITEMS—continued.

	Test 191.	Test 192.
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	7.44	7.58
Per pound of dry coal.....do....	8.05	8.31
Per pound of combustible.....do....	10.04	9.42
Efficiency of boiler, including grate.....per cent..	66.42	61.54
Coal as fired:		
Per indicated horsepower hour.....pounds..	3.80	3.73
Per electrical horsepower hour.....do....	4.69	4.61
Dry coal:		
Per indicated horsepower hour.....do....	3.51	3.40
Per electrical horsepower hour.....do....	4.34	4.20

ANALYSES.

	Test 191.	Test 192.		Test 191.	Test 192.
Proximate.			*Ultimate.*		
Moisture	7.59	8.80	Carbon[a]	63.31	71.08
Volatile matter	35.43	40.26	Hydrogen[a]	4.61	5.17
Fixed carbon	40.64	42.12	Oxygen[a]	7.70	8.63
Ash	16.34	8.82	Nitrogen[a]	1.12	1.26
	100.00	100.00	Sulphur	5.58	4.19
Sulphur	5.16	3.82	Ash	17.68	9.67
				100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 119, Ohio No. 1.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal.....pounds..	26,900
Washed coal.....do....	23,750
Refuse.....do....	3,150

ANALYSES.

	Test 119.	
	Raw coal.	Washed coal.
Moisture	7.71	9.25
Volatile matter	38.32	.....
Fixed carbon	42.02	.....
Ash	11.95	8.57
Sulphur	4.61	3.72

COKING TEST.

Test 24, Ohio No. 1, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 48 hours.

Coal charged	pounds	10,000
Coke produced	do	5,708
Breeze produced	do	5.89
Coke produced	per cent	57.08
Breeze produced	do	5.89
Total percentage yield		62.97

Remarks.—Light gray and silvery. Fingered coke. High ash and sulphur.

ANALYSES.

	Test 24.	
	Coal.	Coke.
Moisture	8.67	1.30
Volatile matter	38.81	1.95
Fixed carbon	44.02	82.98
Ash	8.50	13.77
Sulphur	3.70	3.30

OHIO NO. 2.

Bituminous coal from mine No. 10, Superior Coal Company, 9 miles southeast of Wellston, Jackson County, Ohio, on the Baltimore and Ohio Railroad.

This sample consisted of run-of-mine coal from bed No. 5, both No. 4 and No. 5 seams being worked in this mine.[a] The sample was shipped under the supervision of Inspector W. J. Von Borries, and was used in making washing test No. 121, coking test No. 27, steaming test No. 193, and steaming test on washed coal No. 197.

Two mine samples were taken in this mine for chemical analysis. No. 1898 was cut from room 5, off the second right entry on the south side of the mine, 800 feet southwest of the opening on No. 5 seam. No. 1899 was taken in room 7, off the fourth right entry on the north side of the mine, 800 feet northeast of the opening on seam No. 5.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1898	1899	2109
Air-drying loss		5.60	5.30	3.60
Proximate.	Moisture	9.38	8.95	9.01
	Volatile matter	36.74	37.82	35.85
	Fixed carbon	46.26	43.89	43.80
	Ash	7.62	9.34	11.34
Ultimate.	Sulphur	4.08	4.41	4.02
	Hydrogen	.....	.....	5.38
	Carbon	.....	.....	62.79
	Nitrogen	.....	.....	1.20
	Oxygen	.....	.....	15.27
Calorific value determined:				
	Calories	6,610	.....	6,386
	British thermal units	11,898	.....	11,495

[a] For tests of No. 4 coal, see Ohio No. 1 (p. 140).

STEAMING TESTS.

Test 193, Ohio No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 30.2 per cent; ½ inch to 1 inch, 25 per cent; ¼ inch to ½ inch, 16.6 per cent; under ¼ inch, 28.2 per cent. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 197, Ohio No. 2, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 34 per cent; ½ inch to 1 inch, 23.3 per cent; ¼ inch to ½ inch, 17.4 per cent; under ¼ inch, 25.3 per cent. Duration of test, 9.87 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 193.	Test 197.
Heating value of coal.....B. T. U. per pound dry coal..	12,190	13,113
Force of draft:		
Under stack damper.....inch water..	0.51	0.45
Above fire.....do....	.18	.20
Furnace temperature.....°F..	2,293	2,294
Dry coal used per square foot of grate surface per hour.....pounds..	20.60	18.47
Equivalent water evaporated per square foot of water-heating surface per hour, pounds.....	2.86	3.01
Percentage of rated horsepower of boiler developed.....	80.3	84.4
Water apparently evaporated per pound of coal as fired.....pounds..	6.03	6.32
Water evaporated from and at 212° F:		
Per pound of coal as fired.....do....	7.06	7.43
Per pound of dry coal.....do....	7.75	8.16
Per pound of combustible.....do....	9.57	9.28
Efficiency of boiler, including grate.....per cent..	61.40	60.09
Coal as fired:		
Per indicated horsepower hour.....pounds..	4.01	3.81
Per electrical horsepower hour.....do....	4.95	4.70
Dry coal:		
Per indicated horsepower hour.....do....	3.65	3.47
Per electrical horsepower hour.....do....	4.51	4.28

ANALYSES.

	Test 193.	Test 197.		Test 193.	Test 197.
Proximate.			*Ultimate.*		
Moisture	8.86	8.99	Carbon[a]	66.46	73.09
Volatile matter	35.01	37.71	Hydrogen[a]	4.64	5.11
Fixed carbon	42.32	45.56	Oxygen[a]	7.69	8.43
Ash	13.81	7.74	Nitrogen[a]	1.27	1.41
	100.00	100.00	Sulphur	4.79	3.46
Sulphur	4.37	3.15	Ash	15.15	8.50
				100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 121, Ohio No. 2.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	32,420
Washed coal	do....	25,625
Refuse	do....	6,795

ANALYSES.

	Test 121.	
	Raw coal.	Washed coal.
Moisture	9.01	10.77
Volatile matter	35.85	.....
Fixed carbon	43.80	.....
Ash	11.34	7.42
Sulphur	4.02	2.95

COKING TEST.

Test 27, Ohio No. 2, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 59 hours.

Coal charged	pounds..	10,000
Coke produced	do....	4,980
Breeze produced	do....	690
Coke produced	per cent..	49.80
Breeze produced	do....	6.90
Total percentage yield		56.70

Remarks.—Dull-gray color. Soft coke. High sulphur.

ANALYSES.

	Test 27.	
	Coal.	Coke.
Moisture	10.38	3.55
Volatile matter	37.30	2.27
Fixed carbon	45.04	82.52
Ash	7.28	11.66
Sulphur	3.07	2.81

OHIO NO. 3.

Bituminous coal from Gosline & Barbour mine, Ohio Mining and Manufacturing Company, Shawnee, Perry County, Ohio, on the Zanesville and Western Railway.

This sample was shipped under the supervision of Inspector J. W. Groves and consisted of run-of-mine coal. The following tests were made: Washing test No. 122, coking test No. 31, steaming test No. 203, and producer-gas test No. 64.

Two mine samples were taken for chemical analysis. No. 1900 was taken in the main entry, 500 feet northeast of the drift mouth, and No. 1901 was cut in the face of entry No. 7, 300 feet northeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1900	1901	2144
Air-drying loss		6.60	5.20	3.90
Proximate.	Moisture	10.78	9.79	9.90
	Volatile matter	34.86	35.74	33.66
	Fixed carbon	48.23	48.46	44.86
	Ash	6.13	6.01	11.58
Ultimate.	Sulphur	1.11	1.43	1.81
	Hydrogen			5.28
	Carbon			63.06
	Nitrogen			1.23
	Oxygen			17.04
Calorific value determined:				
	Calories	6,663		6,265
	British thermal units	11,993		11,77

STEAMING TEST.

Test 203, Ohio No. 3, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 36.2 per cent; ½ inch to 1 inch, 23.8 per cent; ¼ inch to ½ inch, 17.5 per cent; under ¼ inch, 22.5 per cent. Duration of test, 9.78 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 203.
Heating value of coal.....B. T. U. per pound dry coal..	13,237
Force of draft:	
Under stack damper.....inch water..	0.47
Above fire.....do....	.12
Furnace temperature.....°F..	2,434
Dry coal used per square foot of grate surface per hour.....pounds..	23.30
Equivalent water evaporated per square foot of water-heating surface per hour.....do....	3.75
Percentage of rated horsepower of boiler developed	105.0
Water apparently evaporated per pound of coal as fired.....pounds..	6.95
Water evaporated from and at 212° F:	
Per pound of coal as fired.....do....	8.17
Per pound of dry coal.....do....	8.97
Per pound of combustible.....do....	10.01
Efficiency of boiler, including grate.....per cent..	65.44
Coal as fired:	
Per indicated horsepower hour.....pounds..	3.46
Per electrical horsepower hour.....do....	4.27
Dry coal:	
Per indicated horsepower hour.....do....	3.15
Per electrical horsepower hour.....do....	3.89

ANALYSES.

	Test 203.		Test 203.
Proximate.		*Ultimate.*	
Moisture	8.88	Carbon [a]	73.77
Volatile matter	34.52	Hydrogen [a]	4.89
Fixed carbon	48.70	Oxygen [a]	9.65
Ash	7.90	Nitrogen [a]	1.44
	100.00	Sulphur	1.58
Sulphur	1.44	Ash	8.67
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 64, Ohio No. 3.

Size as shipped, run of mine. Size as used, over 1 inch, 47 per cent; ½ inch to 1 inch, 38 per cent; ¼ inch to ½ inch, 9 per cent; under ¼ inch, 6 per cent. Duration of test, 50 hours.

Average electrical horsepower	200.8
Average B. T. U. gas, per cubic foot	156.1
Total coal fired, pounds	14,250

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 64.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.52	1.39	1.28
Developed at switch board	1.42	1.30	1.19
Per brake horsepower:			
Available for oustide purposes	1.29	1.18	1.08
Developed at engine	1.21	1.11	1.01
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.62	1.48	1.36
Developed at switch board	1.51	1.39	1.27
Per brake horsepower:			
Available for outside purposes	1.37	1.26	1.16
Developed at engine	1.28	1.18	1.08

ANALYSES.

	Test 64.		Test 64.
Coal.		*Gas by volume.*	
Moisture	8.13	Carbon dioxide (CO_2)	8.2
Volatile matter	34.64	Carbon monoxide (CO)	22.7
Fixed carbon	49.45	Hydrogen (H_2)	15.1
Ash	7.78	Methane (CH_4)	2.5
	100.00	Nitrogen (N_2)	51.5
Sulphur	1.40		100.0

WASHING TEST.

Test 122, Ohio No. 3.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	47,125
Washed coal	do....	34,800
Refuse	do....	12,325

ANALYSES.

	Test 122.	
	Raw coal.	Washed coal.
Moisture	9.90	9.96
Volatile matter	33.66	.....
Fixed carbon	44.86	.....
Ash	11.58	7.74
Sulphur	1.81	1.36

COKING TEST.

Test 31, Ohio No. 3, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 60 hours.
Remarks.—No coke produced.

OHIO NO. 4.

Bituminous coal from Crow Hollow mine, United States Coal Company, Bradley, Jefferson County, Ohio, on the Baltimore and Ohio Railroad.

This sample consisted of "three-fourths inch coal," having been passed over a three-fourths inch bar screen, and was shipped under the supervision of Inspector J. W. Groves. The following tests were made on it: Washing test No. 125, coking test No. 28, steaming tests Nos. 188, 201, and 202, steaming tests on washed coal Nos. 219, 220, and 221, and producer-gas test No. 60.

Two mine samples were taken for chemical analysis, as follows: No. 1910 from room 9 off the fourth left entry in district No. 9, 3,000 feet northwest of the tipple; No. 1911 from room 17 off main entry No. 2 in district No. 2.

CHEMICAL ANALYSES.

		Mine samples		Car samples.
Laboratory number		1910	1911	2083
Air-drying loss		1.70	2.00	1.40
Proximate.	Moisture	4.06	4.20	3.53
	Volatile matter	38.49	37.16	37.45
	Fixed carbon	49.70	51.13	49.90
	Ash	7.75	7.51	9.12
Ultimate.	Sulphur	3.67	3.22	3.47
	Hydrogen	.....	.....	5.15
	Carbon	.....	.....	71.66
	Nitrogen	.....	.....	1.31
	Oxygen	.....	.....	9.29
Calorific value determined:				
	Calories	7,304	.....	7,262
	British thermal units	13,147	.....	13,072

STEAMING TESTS.

Test 188, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 33.3 per cent; ½ inch to 1 inch, 23.5 per cent; ¼ inch to ½ inch, 14.4 per cent; under ¼ inch, 28.8 per cent. Duration of test, 10.13 hours. Kind of grate, plain.

Test 201, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 38.5 per cent; ½ inch to 1 inch, 20.9 per cent; ¼ inch to ½ inch, 13.8 per cent; under ¼ inch, 26.8 per cent. Duration of test, 9.98 hours. Kind of grate, rocking.

Test 202, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 48.2 per cent; ½ inch to 1 inch, 20.8 per cent; ¼ inch to ½ inch, 12.2 per cent; under ¼ inch, 18.8 per cent. Duration of test, 9.38 hours. Kind of grate, rocking.

Test 219, Ohio No. 4, washed.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 30.6 per cent; ½ inch to 1 inch, 23.6 per cent; ¼ inch to ½ inch, 17.8 per cent; under ¼ inch, 28 per cent. Duration of test, 9.92 hours. Kind of grate, plain.

Test 220, Ohio No. 4, washed.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 34.4 per cent; ½ inch to 1 inch, 22.9 per cent; ¼ inch to ½ inch, 15.2 per cent; under ¼ inch, 27.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 221, Ohio No. 4, washed.

Size as shipped, over ¾ inch. Size as used, not determined. Duration of test, 6.30 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 188.	Test 201.	Test 202.	Test 219.	Test 220.	Test 221.
Heating value of coal, B. T. U. per pound dry coal	13,370	13,545	13,374	13,889	13,986	13,986
Force of draft:						
Under stack damper....inch water..	0.47	0.47	0.55	0.42	0.43	0.42
Above fire .....do....	.14	.18	.21	.17	.09	.08
Furnace temperature.....°F..	2,426	2,196	2,289	2,525	2,359	2,312
Dry coal used per square foot of grate surface per hour.....pounds..	19.70	20.60	21.76	17.56	18.60	18.30
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	3.39	3.32	3.55	3.21	3.32	3.29
Percentage of rated horsepower of boiler developed	95.0	93.2	99.5	89.90	93.20	92.1
Water apparently evaporated per pound of coal as fired.....pounds..	7.08	7.37	7.46	7.44	7.26	7.32
Water evaporated from and at 212°F.:						
Per pound of coal as fired..pounds..	8.31	8.66	8.78	8.77	8.56	8.61
Per pound of dry coal.....do....	8.62	9.00	9.10	9.14	8.95	9.00
Per pound of combustible.....do....	9.89	10 32	10.48	10.17	9.84	.....
Efficiency of boiler, including grate, per cent	62.26	64.17	65.71	63.55	61.80	62.14
Coal as fired:						
Per indicated horsepower hour, pounds	3.40	3.27	3.22	3.22	3.30	3.28
Per electrical horsepower hour, pounds	4.20	4.03	3.98	3.98	4.08	4.06
Dry coal:						
Per indicated horsepower hour, pounds	3.28	3.14	3.11	3.09	3.16	3.14
Per electrical horsepower hour, pounds	4.05	3.88	3.84	3.82	3.90	3.88

ANALYSES.

	Test 188.	Test 201.	Test 202.	Test 219.	Test 220.	Test 221.
Proximate.						
Moisture	3.61	3.73	3.60	4.04	4.30	4.30
Volatile matter	37.00	36.73	35.85	38.40	38.86	38.86
Fixed carbon	49.31	49.81	50.54	50.15	50.15	50.15
Ash	10.08	9.73	10.01	7.41	6.69	6.69
	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	3.66	2.65	3.71	3.04	2.97	2.97
Ultimate.						
Carbon[a]	73.26	74.44	73.27	76.13	76.80	76.80
Hydrogen[a]	4.85	4.93	4.87	5.05	5.10	5.10
Oxygen[a]	6.30	6.41	6.29	6.53	6.61	6.61
Nitrogen[a]	1.34	1.36	1.34	1.40	1.40	1.40
Sulphur	3.80	2.75	3.85	3.17	3.10	3.10
Ash	10.45	10.11	10.38	7.72	6.99	6.99
	100.00	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 60, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, not determined. Duration of test, 25 hours.

Average electrical horsepower 202.4
Average B. T. U. gas per cubic foot 148.8
Total coal fired ..... pounds.. 6,300

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 60.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.31	1.24	1.14
Developed at switch board	1.25	1.18	1.09
Per brake horsepower:			
Available for outside purposes	1.11	1.06	.97
Developed at engine	1.06	1.01	.92
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.41	1.33	1.23
Developed at switch board	1.34	1.27	1.17
Per brake horsepower:			
Available for outside purposes	1.20	1.13	1.04
Developed at engine	1.14	1.08	.99

ANALYSES.

	Test 60.		Test 60.
Coal.		*Gas by volume.*	
Moisture	5.03	Carbon dioxide (CO_2)	9.6
Volatile matter	36.68	Carbon monoxide (CO)	20.0
Fixed carbon	50.70	Hydrogen (H_2)	13.0
Ash	7.59	Methane (CH_4)	2.7
	100.00	Nitrogen (N_2)	54.7
Sulphur	2.77		100.0

WASHING TEST.

Test 125, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	29,120
Washed coal	do....	26,000
Refuse	do....	3,120

ANALYSES.

	Test 125.	
	Raw coal.	Washed coal.
Moisture	3.53	3.33
Volatile matter	37.45	.....
Fixed carbon	49.90	.....
Ash	9.12	7.48
Sulphur	3.47	3.27

COKING TEST.

Test 28, Ohio No. 4.

Size as shipped, over ¾ inch. Size as used, finely crushed. Raw. Duration of test, 45 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,770
Breeze produced	do....	332
Coke produced	per cent..	67.70
Breeze produced	do....	3.32
Total percentage yield		71.02

Remarks.—Light-gray and silvery color. Good, heavy coke. High yield due to deposited carbon. High ash and sulphur.

ANALYSES.

	Test 28.	
	Coal.	Coke.
Moisture	3.86	5.33
Volatile matter	37.09	1.28
Fixed carbon	49.38	79.79
Ash	9.67	13.60
Sulphur	3.60	2.87

OHIO NO. 5.

Bituminous coal from Rush Run No. 1 mine, Glens Run Coal Company, Rush Run, Jefferson County, Ohio, on the Pennsylvania Railroad.

This sample consisted of "three-fourths inch coal" which had been passed over a three-fourths inch bar screen. It was shipped under the supervision of Inspector J. W. Groves, and was used in making coking test No. 22, steaming tests Nos. 186, 187, 189, and 190, and producer-gas test No. 58.

Two mine samples were taken for chemical analysis. No. 1944 was cut from a point off the first left entry, 2,400 feet southeast of the drift mouth; No. 1945 was cut from the face of room 17 off the third entry, 2,600 feet south of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1944	1945	2062
Air-drying loss		2.40	2.20	2.40
Proximate.	Moisture	4.69	4.99	4.34
	Volatile matter	35.57	35.33	35.53
	Fixed Carbon	53.73	53.98	52.83
	Ash	6.01	5.70	7.30
Ultimate.	Sulphur	1.54	.95	1.72
	Hydrogen			5.21
	Carbon			72.65
	Nitrogen			1.42
	Oxygen			11.70
Calorific value determined:				
	Calories	7,403		7,321
	British thermal units	13,325		13,178

STEAMING TESTS.

Test 186, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 49.2 per cent; ½ inch to 1 inch, 23.6 per cent; ¼ inch to ½ inch, 11.8 per cent; under ¼ inch, 15.4 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 187, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 44 per cent; ½ inch to 1 inch, 20.2 per cent; ¼ inch to ½ inch, 12 per cent; under ¼ inch, 23.8 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 189, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 28.3 per cent; ½ inch to 1 inch, 19.7 per cent; ¼ inch to ½ inch, 15.6 per cent; under ¼ inch, 36.4 per cent. Duration of test, 10.05 hours. Kind of grate, plain.

Test 190, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 35.1 per cent; ½ inch to 1 inch, 22.7 per cent; ¼ inch to ½ inch, 15.6 per cent; under ¼ inch, 26.6 per cent. Duration of test, 10.07 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 186.	Test 187.	Test 189.	Test 190.
Heating value of coal.....B. T. U. per pound dry coal..	13,684	13,469	13,532	13,450
Force of draft:				
Under stack damper.....inch water..	0.41	0.31	0.42	0.40
Above fire.....do....	.12	.16	.13	.10
Furnace temperature.....°F..	2,673	2,441	2,440	2,503
Dry coal used per square foot of grate surface per hour, pounds.....	21.49	22.91	19.48	20.44
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.80	4.06	3.60	3.70
Percentage of rated horsepower of boiler developed.....	106.4	113.7	100.9	103.7
Water apparently evaporated per pound of coal as fired, pounds.....	7.25	7.20	7.52	7.39

MISCELLANEOUS ITEMS—continued.

	Test 186.	Test 187.	Test 189.	Test 190.
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	8.47	8.45	8.81	8.67
Per pound of dry coal.....do....	8.85	8.87	9.25	9.07
Per pound of combustible.....do....	9.84	9.96	10.34	10.24
Efficiency of boiler, including grate.....per cent..	62.45	63.60	66.01	65.12
Coal as fired:				
Per indicated horsepower hour.....pounds..	3.34	3.35	3.21	3.26
Per electrical horsepower hour.....do....	4.12	4.13	3.96	4.03
Dry coal:				
Per indicated horsepower hour.....do....	3.20	3.19	3.06	3.12
Per electrical horsepower hour.....do....	3.95	3.94	3.77	3.85

ANALYSES.

	Test 186.	Test 187.	Test 189.	Test 190.
Proximate.				
Moisture	4.25	4.74	4.74	4.43
Volatile matter	34.40	33.04	34.37	34.52
Fixed carbon	53.41	52.97	52.21	51.73
Ash	7.94	9.25	8.68	9.32
	100.00	100.00	100.00	100.00
Sulphur	1.63	1.63	1.86	1.76
Ultimate.				
Carbon [a]	75.47	74.27	74.57	74.14
Hydrogen [a]	4.91	4.83	4.85	4.82
Oxygen [a]	8.16	8.03	8.07	8.01
Nitrogen [a]	1.47	1.45	1.45	1.44
Sulphur	1.70	1.71	1.95	1.84
Ash	8.29	9.71	9.11	9.75
	100.00	100.00	100.00	100.0

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 58, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower..... 202.2
Average B. T. U. gas, per cubic foot..... 152.3
Total coal fired.....pounds.. 11,850

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 58.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.25	1.19	1.12
Developed at switch board	1.17	1.12	1.05
Per brake horsepower:			
Available for outside purposes	1.06	1.01	.95
Developed at engine	1.00	0.95	.89

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR)—continued.

	Test 58.		
	Coal as fired.	Dry coal.	Combustible.
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.34	1.28	1.20
Developed at switch board	1.26	1.20	1.13
Per brake horsepower:			
Available for outside purposes	1.13	1.09	1.02
Developed at engine	1.07	1.02	.96

ANALYSES.

	Test 58.		Test 58.
Coal.		*Gas by volume.*	
Moisture	4.39	Carbon dioxide (CO_2)	8.9
Volatile matter	35.91	Carbon monoxide (CO)	20.7
Fixed carbon	53.77	Hydrogen (H_2)	12.7
Ash	5.93	Methane (CH_4)	3.0
	100.00	Nitrogen (N_2)	54.7
Sulphur	1.42		100.0

COKING TEST.

Test 22, Ohio No. 5.

Size as shipped, over ¾ inch. Size as used, finely crushed. Raw. Duration of test, 55 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,383
Breeze produced	do....	358
Coke produced	per cent..	63.83
Breeze produced	do....	3.58
Total percentage yield		67.41

Remarks: Light-gray and silvery color. Good, strong coke. Should make good furnace coke. Washing would probably reduce ash and sulphur and make good foundry coke. High yield due to deposited carbon.

ANALYSES.

	Test 22.	
	Coal.	Coke.
Moisture	4.49	0.87
Volatile matter	34.57	.98
Fixed carbon	52.85	86.15
Ash	8.09	12.00
Sulphur	1.77	1.64

OHIO NO. 6.

Bituminous coal from mine No. 1, Neff Coal Mining Company, Neffs, Belmont County, Ohio, on the Baltimore and Ohio Railroad.

This sample, which consisted of run-of-mine coal, was shipped under the supervision of Inspector W. J. Von Borries and was used in making washing test No. 133, coking tests Nos. 59 and 66, steaming test No. 284, steaming test on washed coal No. 253, and producer-gas test No. 76.

Two mine samples were taken for chemical analysis as follows: No. 2095 from room 12 off the fourth east entry, 2,000 feet southeast of the drift mouth; No. 2096 in room 3 off the second west entry, 1,000 feet southwest of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2095	2096	2392
Air-drying loss		1.80	1.80	3.90
Proximate.	Moisture	3.99	4.06	5.31
	Volatile matter	38.77	39.45	36.72
	Fixed carbon	49.17	50.05	49.45
	Ash	8.07	6.44	8.52
Ultimate.	Sulphur	3.49	3.35	3.33
	Hydrogen			5.39
	Carbon			70.71
	Nitrogen			1.12
	Oxygen			10.93
Calorific value determined:				
	Calories	7,279		7,135
	British thermal units	13,102		12,843

STEAMING TESTS.

Test 284, Ohio No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 49 per cent; ½ inch to 1 inch, 14.3 per cent; ¼ inch to ½ inch, 10.9 per cent; under ¼ inch, 25.8 per cent. Duration of test, 9.93 hours. Kind of grate, rocking.

Test 253, Ohio No. 6, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 40 per cent; ½ inch to 1 inch, 24.1 per cent; ¼ inch to ½ inch, 13.7 per cent; under ¼ inch, 22.2 per cent. Duration of test, 8.2 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 284.	Test 253.
Heating value of coal	B. T. U. per pound dry coal	12,974	13,901
Force of draft:			
Under stack damper	inch water	0.41	0.45
Above fire	do	.12	.18
Furnace temperature	°F.	2,334	2,332
Dry coal used per square foot of grate surface per hour	pounds	17.88	15.73
Equivalent water evaporated per square foot of water-heating surface per hour, pounds		2.90	2.83
Percentage of rated horsepower of boiler developed		81.3	79.4
Water apparently evaporated per pound of coal as fired	pounds	7.27	7.32
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	8.71	8.73
Per pound of dry coal	do	9.04	9.02
Per pound of combustible	do	10.60	9.93
Efficiency of boiler, including grate	per cent	67.29	62.66
Coal as fired:			
Per indicated horsepower hour	pounds	3.25	3.24
Per electrical horsepower hour	do	4.01	4.00
Dry coal:			
Per indicated horsepower hour	do	3.13	3.13
Per electrical horsepower hour	do	3.86	3.87

ANALYSES.

	Test 284.	Test 253.		Test 284.	Test 253.
Proximate.			*Ultimate.*		
Moisture	3.71	3.26	Carbon[a]	71.32	76.63
Volatile matter	36.58	38.74	Hydrogen[a]	4.84	5.21
Fixed carbon	47.64	51.12	Oxygen[a]	6.26	6.72
Ash	12.07	6.88	Nitrogen[a]	1.13	1.22
	100.00	100.00	Sulphur	3.91	3.11
Sulphur	3.77	3.01	Ash	12.54	7.11
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 76, Ohio No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 61 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 10 per cent; under ¼ inch, 15 per cent. Duration of test, 50 hours.

Average electrical horsepower	195.6
Average B. T. U. gas, per cubic foot	163.4
Total coal fired, pounds	11,850

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 76.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.27	1.23	1.12
Developed at switch board	1.21	1.17	1.06
Per brake horsepower:			
Available for outside purposes	1.08	1.04	.95
Developed at engine	1.03	.99	.90
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.36	1.31	1.20
Developed at switch board	1.30	1.25	1.14
Per brake horsepower:			
Available for outside purposes	1.16	1.12	1.02
Developed at engine	1.10	1.06	.97

ANALYSES.

	Test 76.		Test 76.
Coal.		*Gas by volume.*	
Moisture	3.61	Carbon dioxide (CO_2)	10.4
Volatile matter	38.05	Carbon monoxide (CO)	19.1
Fixed carbon	49.68	Hydrogen (H_2)	14.1
Ash	8.66	Methane (CH_4)	3.6
	100.00	Nitrogen (N_2)	52.8
Sulphur	3.76		100.0

WASHING TEST.

Test 133, Ohio No. 6.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	24,000
Washed coal	do....	20,400
Refuse	do....	3,600

ANALYSES.

	Test 133.	
	Raw coal.	Washed coal.
Moisture	5.31	6.16
Volatile matter	36.72	.....
Fixed carbon	49.45	.....
Ash	8.52	6.38
Sulphur	3.33	2.94

COKING TESTS.

Test 59, Ohio No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 46 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,200
Breeze produced	do....	370
Coke produced	per cent..	60.00
Breeze produced	do....	3.08
Total percentage yield		63.08

Remarks.—Light gray and silvery. Large, long, heavy pieces. Ash and sulphur high. Would make very good coke if these impurities could be removed by washing.

Test 66, Ohio No. 6, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 60 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,166
Breeze produced	do....	369
Coke produced	per cent..	59.72
Breeze produced	do....	3.08
Total percentage yield		62.80

Remarks.—Light gray and silvery. Washing does not materially reduce ash and sulphur, and coke from washed coal not as good physically as that from raw charge.

ANALYSES.

	Test 59.		Test 66.	
	Coal.	Coke.	Coal.	Coke.
Moisture	5.26	0.77	5.53	0.42
Volatile matter	37.36	1.26	36.95	1.20
Fixed carbon	47.53	83.71	50.96	88.35
Ash	9.85	14.26	6.56	10.03
Sulphur	3.49	2.96	2.96	2.51

OHIO NO. 7.

Bituminous coal from Forsythe mine, Forsythe Coal Company, Danford, Guernsey County, Ohio, on the Baltimore and Ohio Railroad.

This sample was shipped as "lump coal," having been passed over a 1¼-inch bar screen. It was loaded under the supervision of Inspector J. W. Groves and was used in making washing test No. 138, coking tests Nos. 89 and 94, steaming tests Nos. 268 and 269, and producer-gas test No. 87.

Two mine samples were taken for chemical analysis. No. 2090 was cut from the face of room 1 off the sixteenth east entry, 2,600 feet northwest of the bottom of the slope. No. 2091 was taken in room 22 off the fourteenth east entry, 3,700 feet north from the *bottom of the slope.*

CHEMICAL ANALYSES.

		Mine samples.		Boiler test sample.
Laboratory number		2090	2091	2656
Air-drying loss		2.60	2.20	2.60
Proximate.	Moisture	6.28	5.80	6.65
	Volatile matter	35.81	36.89	33.94
	Fixed carbon	50.61	50.73	48.86
	Ash	7.30	6.58	10.55
Ultimate.	Sulphur	3.55	2.62	3.13
	Hydrogen	.....	.....	5.30
	Carbon	.....	.....	67.38
	Nitrogen	.....	.....	1.20
	Oxygen	.....	.....	12.44
Calorific value determined:				
	Calories	7,056	.....	6,766
	British thermal units	12,701	.....	12,179

STEAMING TESTS.

Test 268, Ohio No. 7.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 41.1 per cent; ½ inch to 1 inch, 18.5 per cent; ¼ inch to ½ inch, 14.1 per cent; under ¼ inch, 26.3 per cent. Duration of test, 9.92 hours. Kind of grate, plain.

Test 269, Ohio No. 7.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 50.7 per cent; ½ inch to 1 inch, 19.9 per cent; ¼ inch to ½ inch, 11.5 per cent; under ¼ inch, 17.9 per cent. Duration of test, 8.27 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 268.	Test 269.
Heating value of coal.....B. T. U. per pound dry coal..	13,046	13,079
Force of draft:		
Under stack damper.....inch water..	0.40	0.55
Above fire.....do....	.13	.18
Furnace temperature.....°F..	2,280	2,453
Dry coal used per square foot of grate surface per hour.....pounds..	15.96	18.55
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.87	3.24
Percentage of rated horsepower of boiler developed	80.3	90.9
Water apparently evaporated per pound of coal as fired.....pounds..	7.03	6.85
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	8.40	8.20
Per pound of dry coal.....do....	9.00	8.76
Per pound of combustible.....do....	10.37	10.06
Efficiency of boiler, including grate.....per cent..	66.62	64.68
Coal as fired:		
Per indicated horsepower hour.....pounds..	3.37	3.45
Per electrical horsepower hour.....do....	4.16	4.26
Dry coal:		
Per indicated horsepower hour.....do....	3.14	3.23
Per electrical horsepower hour.....do....	3.88	3.99

ANALYSES.

	Test 268.	Test 269.		Test 268.	Test 269.
Proximate.			*Ultimate.*		
Moisture	6.65	6.42	Carbon[a]	72.19	72.34
Volatile matter	33.94	34.20	Hydrogen[a]	4.89	4.90
Fixed carbon	48.86	49.14	Oxygen[a]	6.98	7.00
Ash	10.55	10.24	Nitrogen[a]	1.29	1.29
	100.00	100.00	Sulphur	3.35	3.53
Sulphur	3.13	3.30	Ash	11.30	10.94
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 87, Ohio No. 7.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 72 per cent; ½ inch to 1 inch, 12 per cent; ¼ to ½ inch, 6 per cent; under ¼ inch, 10 per cent. Duration of test, 41 hours.

Average electrical horsepower	198.0
Average B. T. U. gas, per cubic foot	156.2
Total coal fired ..... pounds..	12,850

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 87.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.67	1.58	1.44
Developed at switch board	1.58	1.50	1.37
Per brake horsepower:			
Available for outside purposes	1.42	1.34	1.23
Developed at engine	1.35	1.27	1.16
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.76	1.67	1.52
Developed at switch board	1.67	1.58	1.45
Per brake horsepower:			
Available for outside purposes	1.50	1.41	1.30
Developed at engine	1.42	1.35	1.23

ANALYSES.

	Test 87.		Test 87.
Coal.		*Gas by volume.*	
Moisture	5.29	Carbon dioxide (CO_2)	9.5
Volatile matter	35.86	Carbon monoxide (CO)	20.4
Fixed carbon	50.73	Hydrogen (H_2)	12.3
Ash	8.12	Methune (CH_4)	3.1
	100.00	Nitrogen (N_2)	54.7
Sulphur	2.34		100.0

WASHING TEST.

Test 138, Ohio No. 7.

Size as shipped, over 1¼ inches. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	16,000
Washed coal	do....	14,000
Refuse	do....	2,000

ANALYSES.

	Test 138.	
	Raw coal.	Washed coal.
Moisture	6.65	7.47
Volatile matter	33.94	.....
Fixed carbon	48.86	.....
Ash	10.55	6.37
Sulphur	3.13	2.16

COKING TESTS.

Test 89, Ohio No. 7.

Size as shipped, over 1¼ inches. Size as used, finely crushed. Raw. Duration of test, 45 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,117
Breeze produced	do....	374
Coke produced	per cent..	59.31
Breeze produced	do....	3.12
Total percentage yield		62.43

Remarks.—Light gray and silvery. Large-fingered coke. Ash and sulphur high.

Test 94, Ohio No. 7, washed.

Size as shipped, over 1¼ inches. Size as used, finely crushed. Duration of test, 60 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,898
Breeze produced	do....	303
Coke produced	per cent..	57.49
Breeze produced	do....	2.53
Total percentage yield		60.02

Remarks. Light gray and silvery. Fine-fingered coke. Lighter than coke from raw coal. Washing does not improve; sulphur high.

ANALYSES.

	Test 89.		Test 94.	
	Coal.	Coke.	Coal.	Coke.
Moisture	5.77	0.75	7.37	0.57
Volatile matter	35.43	.98	36.36	1.58
Fixed carbon	49.82	85.33	49.72	88.08
Ash	8.98	12.94	6.55	9.77
Sulphur	2.88	1.32	2.23	1.90

OHIO NO. 8.

Bituminous coal from Dixie mine, Upson Coal and Mining Company, Dixie, Perry County Ohio, on the Baltimore and Ohio Railroad.

This sample consisted of run-of-mine coal. It was loaded under the supervision of Inspector J. W. Groves and was used in making washing test No. 137, coking tests Nos. 81 and 93, steaming test No. 287, and producer-gas test No. 83.

Two mine samples were taken in the mine for chemical analysis—No. 2119 from the first pair of east entries, 1,000 feet southeast of the drift mouth, and No. 2120 from the first pair of west entries, 1,000 feet southwest of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2119	2120	2559
Air-drying loss		3.80	3.70	4.50
Proximate.	Moisture	8.92	8.87	7.55
	Volatile matter	38.58	39.32	38.00
	Fixed carbon	46.65	47.81	46.08
	Ash	5.85	4.00	8.37
Ultimate.	Sulphur	3.00	1.74	2.84
	Hydrogen	.....	.....	5.48
	Carbon	.....	.....	67.02
	Nitrogen	.....	.....	1.29
	Oxygen	.....	.....	15.00
Calorific value determined:				
	Calories	6,849	.....	6,738
	British thermal units	12,328	.....	12,128

STEAMING TEST.

Test 287, Ohio No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 50.2 per cent; ½ inch to 1 inch, 20.4 per cent; ¼ inch to ½ inch, 11.8 per cent; under ¼ inch, 17.6 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 287.
Heating value of coal ..... B. T. U. per pound dry coal..	13,136
Force of draft:	
Under stack damper ..... inch water..	0.50
Above fire ..... do....	.21
Furnace temperature ..... °F..	2,596
Dry coal used per square foot of grate surface per hour ..... pounds..	21.29
Equivalent water evaporated per square foot of water heating surface per hour ..... do....	3.44
Percentage of rated horsepower of boiler developed	96.3
Water apparently evaporated per pound of coal as fired ..... pounds..	6.86
Water evaporated from and at 212° F.:	
Per pound of coal as fired ..... do....	8.22
Per pound of dry coal ..... do....	9.01
Per pound of combustible ..... do....	10.08
Efficiency of boiler, including grate ..... per cent..	66.24
Coal as fired:	
Per indicated horsepower hour ..... pounds..	3.44
Per electrical horsepower hour ..... do....	4.25
Dry coal:	
Per indicated horsepower hour ..... do....	3.14
Per electrical horsepower hour ..... do....	3.88

ANALYSES.

	Test 287.		Test 287.
Proximate.		*Ultimate.*	
Moisture	8.70	Carbon[a]	72.70
Volatile matter	35.76	Hydrogen[a]	5.04
Fixed carbon	47.10	Oxygen[a]	8.98
Ash	8.44	Nitrogen[a]	1.40
	100.00	Sulphur	2.64
Sulphur	2.41	Ash	9.24
			100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 83, Ohio No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 58 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 9 per cent; under ¼ inch, 19 per cent. Duration of test, 50 hours.

Average electrical horsepower	198.6
Average B. T. U. gas, per cubic foot	170.2
Total coal fired.....pounds..	14,850

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 83.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.60	1.47	1.27
Developed at switch board	1.50	1.37	1.19
Per brake horsepower:			
Available for outside purposes	1.36	1.25	1.08
Developed at engine	1.27	1.17	1.01
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.67	1.53	1.32
Developed at switch board	1.56	1.42	1.23
Per brake horsepower:			
Available for outside purposes	1.42	1.30	1.12
Developed at engine	1.32	1.21	1.05

ANALYSES.

	Test 83.		Test 83.
Coal.		*Gas by volume.*	
Moisture	8.70	Carbon dioxide (CO_2)	6.5
Volatile matter	35.58	Carbon monoxide (CO)	24.5
Fixed carbon	43.63	Hydrogen (H_2)	12.3
Ash	12.09	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	53.6
Sulphur	3.82		100.00

WASHING TEST.

Test 137, Ohio No. 8.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	17,200
Washed coal	do....	15,560
Refuse	do....	1,640

ANALYSES.

	Test 137.	
	Raw coal.	Washed coal.
Moisture	7.55	11.77
Volatile matter	38.00	.....
Fixed carbon	46.08	.....
Ash	8.37	6.03
Sulphur	2.84	2.07

COKING TESTS.

Test 81, Ohio No. 8.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 52 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,526
Breeze produced	do....	454
Coke produced	per cent..	54.38
Breeze produced	do....	3.78
Total percentage yield		58.16

Remarks.—Light gray and silvery. Fine-fingered coke. High ash and sulphur.

Test 93, Ohio No. 8, washed.

Size as shipped, run of mine. Size as used finely crushed. Duration of test, 69 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,281
Breeze produced	do....	433
Coke produced	per cent..	52.34
Breeze produced	do....	3.61
Total percentage yield		55.95

Remarks.—Light gray, with some little silvery deposit. About three-fourths of oven seemed to coke up about 8 inches and upper 16 inches coked down, showing clear demarcation. Upper part fingered, lower in chunks. Washing does not improve.

ANALYSES.

	Test 81.		Test 93.	
	Coal.	Coke.	Coal.	Coke.
Moisture	8.43	0.66	11.43	2.46
Volatile matter	37.25	.93	37.90	1.76
Fixed carbon	44.56	82.81	44.64	86.05
Ash	9.76	15.60	6.03	9.73
Sulphur	2.90	2.59	2.10	1.88

OHIO NO. 9.

Bituminous coal from Clarion mine, Gallia Mining Company, Clarion, Vinton County, Ohio, on the Hocking Valley Railway.

Two samples were shipped under the supervision of Inspector J. W. Groves, as follows: Ohio No. 9 A, lump coal over 1¼-inch screen, used in making coking test No. 72, steaming tests Nos. 246, 249, 250, and 252, and producer-gas test No. 73; Ohio No. 9 B, nut and slack coal through 1¼-inch screen, used in making washing test No. 131, coking tests Nos. 55 and 57, steaming test No. 224, and steaming tests on washed coal Nos. 241, 243, and 244.

Two mine samples were taken in this mine for chemical analysis—No. 2208 from room 6 off the fourth east entry, 900 feet northeast of the drift mouth, and No. 2209 from No. 5 butt entry off the main entry, 800 feet west of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample A.	Car sample B.
Laboratory number		2208	2209	2310	2311
Air-drying loss		2.80	3.40	3.20	5.60
Proximate.	Moisture	6.79	7.38	5.59	8.10
	Volatile matter	40.01	41.60	36.86	36.87
	Fixed carbon	45.54	44.86	49.26	43.10
	Ash	7.66	6.16	8.29	11.93
Ultimate.	Sulphur	3.34	2.77	3.15	3.35
	Hydrogen	.....	.....	4.88	5.15
	Carbon	.....	.....	69.76	63.54
	Nitrogen	.....	.....	1.18	1.06
	Oxygen	.....	.....	12.74	14.97
Calorific value determined:					
Calories		6,952	.....	7,096	6,424
British thermal units		12,514	.....	12,773	11,563

STEAMING TESTS.

Test 246, Ohio No. 9 A.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 48.5 per cent; ½ inch to 1 inch, 17.7 per cent; ¼ inch to ½ inch, 11.2 per cent; under ¼ inch, 22.6 per cent. Duration of test, 8 hours. Kind of grate, plain.

Test 249, Ohio No. 9 A.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 58 per cent; ½ inch to 1 inch, 14.5 per cent; ¼ inch to ½ inch, 8.7 per cent; under ¼ inch, 18.8 per cent. Duration of test, 9.80 hours. Kind of grate, plain.

Test 250, Ohio No. 9 A.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 45.8 per cent; ½ inch to 1 inch, 17.6 per cent; ¼ inch to ½ inch, 14.1 per cent; under ¼ inch, 22.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 252, Ohio No. 9 A.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 35.4 per cent; ½ inch to 1 inch, 16.5 per cent; ¼ inch to ½ inch, 16 per cent; under ¼ inch, 32.1 per cent. Duration of test, 6.63 hours. Kind of grate, plain.

Test 224, Ohio No. 9 B.

Size as shipped, nut and slack. Size as used, over 1 inch, 20.6 per cent; ½ inch to 1 inch, 20.7 per cent; ¼ inch to ½ inch, 16.8 per cent; under ¼ inch, 41.9 per cent. Duration of test, 9.88 hours. Kind of grate, rocking.

Test 241, Ohio No. 9 B, washed.

Size as shipped, nut and slack. Size as used, over 1 inch, 28.1 per cent; ½ inch to 1 inch, 26.9 per cent; ¼ inch to ½ inch, 19 per cent; under ¼ inch, 26 per cent. Duration of test, 8.08 hours. Kind of grate, plain.

Test 243, Ohio No. 9 B, washed and dried.

Size as shipped, nut and slack. Size as used, over 1 inch, 11.7 per cent; ½ inch to 1 inch, 22.8 per cent; ¼ inch to ½ inch, 23.8 per cent; under ¼ inch, 41.7 per cent. Duration of test, 9.45 hours. Kind of grate, plain.

Test 244, Ohio No. 9 B, washed and dried.

Size as shipped, nut and slack. Size as used, over 1 inch, 16.6 per cent; ½ inch to 1 inch, 29.8 per cent; ¼ inch to ½ inch, 22.6 per cent; under ¼ inch, 31 per cent. Duration of test, 6.07 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 246.	Test 249.	Test 250.	Test 252.	Test 224.	Test 241.	Test 243.	Test 244.
Heating value of coal, B. T. U. per pound dry coal	13,507	13,390	13,369	13,406	12,119	13,504	13,374	13,421
Force of draft:								
Under stack damper, inch water	0.48	0.38	0.37	0.42	0.59	0.47	0.49	0.44
Above fire.....do....	.15	.13	.11	.14	.18	.11	.13	.11
Furnace temperature.....°F..	2,400	2,411	2,322	2,436	.....	2,349	2,487	2,532
Dry coal used per square foot of grate surface per hour...pounds..	18.30	16.50	15.64	17.39	21.51	17.81	18.22	18.08
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.32	2.93	2.88	3.13	3.13	3.31	3.31	3.26
Percentage of rated horsepower of boiler developed	93.1	82.1	80.7	87.9	87.8	92.7	92.8	91.5
Water apparently evaporated per pound of coal as fired...pounds..	7.20	7.00	7.26	7.11	6.32	7.18	7.48	7.41
Water evaporated from and at 212° F.:								
Per pound of coal as fired, pounds	8.57	8.33	8.66	8.49	7.48	8.56	8.93	8.82
Per pound of dry coal.pounds..	9.10	8.90	9.22	9.03	8.12	9.30	9.11	9.04
Per pound of combustible, pounds	10.06	9.96	10.31	10.10	9.97	10.17	9.98	9.86
Efficiency of boiler, including grate, per cent	65.06	64.19	66.60	65.05	64.70	66.51	65.78	65.05
Coal as fired:								
Per indicated horsepower hour, pounds	3.30	3.40	3.26	3.33	3.78	3.30	3.17	3.21
Per electrical horsepower hour, pounds	4.08	4.19	4.03	4.11	4.67	4.08	3.91	3.96
Dry coal:								
Per indicated horsepower hour, pounds	3.11	3.18	3.07	3.13	3.48	3.04	3.10	3.13
Per electrical horsepower hour, pounds	3.84	3.92	3.79	3.87	4.30	3.75	3.83	3.86

ANALYSES.

	Test 246.	Test 249.	Test 250.	Test 252.	Test 224.	Test 241.	Test 243.	Test 244.
Proximate.								
Moisture	5.83	6.40	6.06	5.99	7.84	7.92	1.92	2.47
Volatile matter	40.02	37.82	38.44	38.99	35.24	38.58	41.68	41.33
Fixed carbon	46.23	47.06	46.66	46.31	42.03	46.42	48.99	49.15
Ash	7.92	8.72	8.84	8.71	14.89	7.08	7.41	7.05
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sulphur	3.76	3.60	3.66	3.50	3.27	2.86	3.06	3.02
Ultimate.								
Carbon [a]	73.64	73.00	72.89	73.15	66.59	73.97	73.18	73.45
Hydrogen [a]	4.50	4.45	4.45	4.47	4.46	4.95	5.05	5.06
Oxygen [a]	8.22	8.14	8.12	8.17	8.13	9.04	9.86	9.91
Nitrogen [a]	1.24	1.24	1.23	1.23	1.11	1.24	1.24	1.25
Sulphur	3.99	3.85	3.90	3.72	3.55	3.11	3.12	3.10
Ash	8.41	9.32	9.41	9.26	16.16	7.69	7.55	7.23
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 73, Ohio No. 9 A.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 62 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 11 per cent; under ¼ inch, 13 per cent. Duration of test, 50 hours.

Average electrical horsepower		194.5
Average B. T. U. gas, per cubic foot		154.6
Total coal fired	pounds..	12,800

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 73.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.39	1.29	1.17
Developed at switch board	1.32	1.22	1.11
Per brake horsepower:			
Available for outside purposes	1.18	1.10	1.00
Developed at engine	1.12	1.04	.95
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.51	1.40	1.27
Developed at switch board	1.43	1.32	1.21
Per brake horsepower:			
Available for outside purposes	1.28	1.19	1.08
Developed at engine	1.21	1.13	1.03

ANALYSES.

	Test 73.		Test 73.
Coal.		*Gas by volume.*	
Moisture	7.22	Carbon dioxide (CO_2)	14.5
Volatile matter	38.32	Carbon monoxide (CO)	13.8
Fixed carbon	46.23	Hydrogen (H_2)	18.1
Ash	8.23	Methane (CH_4)	3.0
	100.00	Nitrogen (N_2)	50.6
Sulphur	3.52		100.0

WASHING TEST.

Test 131, Ohio No. 9 B.

Size as shipped, nut and slack. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	46,530
Washed coal	do....	37,830
Refuse	do....	8,700

ANALYSES.

	Test 131.	
	Raw coal.	Washed coal.
Moisture	8.10	9.49
Volatile matter	36.87	.....
Fixed carbon	43.10	.....
Ash	11.93	7.45
Sulphur	3.35	2.88

COKING TESTS.

Test 72, Ohio No. 9 A.

Size as shipped, over 1¼ inches. Size as used, finely crushed. Raw. Duration of test, 71 hours.

Coal charged	pounds..	12,000
Coke produced	do....	5,596
Breeze produced	do....	452
Coke produced	per cent..	54.97
Breeze produced	do....	3.77
Total percentage yield		58.74

Remarks.—Light gray and silvery. Fine-fingered coke. Sulphur too high. Good coke can be produced if sulphur can be lowered by washing. Somewhat brittle.

Test 55, Ohio No. 9 B.

Size as shipped, nut and slack. Size as used, finely crushed. Raw. Duration of test, 53 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,647
Breeze produced	do....	593
Coke produced	per cent..	55.39
Breeze produced	do....	4.96
Total percentage yield		60.35

Remarks.—Dull-gray color. Some little deposited carbon. Good weight coke. Breaks in about equal proportions of fingered coke and chunks. High ash and sulphur.

Test 57, Ohio No. 9 B, washed.

Size as shipped, nut and slack. Size as used, finely crushed. Duration of test, 57 hours.

Coal charged	pounds..	12,000
Coke produced	do....	6,300
Breeze produced	do....	441
Coke produced	per cent..	52.50
Breeze produced	do....	3.68
Total percentage yield		56.18

Remarks.—Light-gray color. Fine-fingered coke. Somewhat brittle. Washing reduces ash very materially, but does not remove sufficient sulphur.

ANALYSES.

	Test 72.		Test 55.		Test 57.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	5.58	1.80	9.03	0.70	9.73	0.68
Volatile matter	39.80	1.08	33.56	1.35	37.27	.89
Fixed carbon	46.44	84.43	41.10	78.63	46.02	86.93
Ash	8.18	12.69	16.31	19.32	6.98	11.50
Sulphur	3.63	3.06	3.40	2.94	2.84	2.40

PENNSYLVANIA NO. 4.

Bituminous coal from Jamison mine, Jamison Coal and Coke Company, 4 miles north of Greensburg, Westmoreland County, Pa., on the Pennsylvania Railroad.

This sample consisted of lump coal (over 1¼-inch bar screen) and was shipped under the supervision of Inspector J. W. Groves. The following tests were made: Steaming tests Nos. 207, 208, and 209, and producer-gas test No. 65.

Two mine samples for chemical analysis were taken from this mine—No. 1942 from the face of room 19 off the tenth butt entry, 3,500 feet north of the shaft, and No. 1943 in the main west entry, 2,000 feet northwest of the shaft.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1942	1943	2187
Air-drying loss		1.60	1.70	2.20
Proximate.	Moisture	2.73	2.80	3.15
	Volatile matter	30.34	30.92	30.27
	Fixed carbon	57.80	58.21	56.17
	Ash	9.13	8.07	10.41
Ultimate.	Sulphur	1.33	.83	1.26
	Hydrogen			4.96
	Carbon			74.33
	Nitrogen			1.43
	Oxygen			7.61
Calorific value determined:				
	Calories	7,563		7,448
	British thermal units	13,613		13,406

STEAMING TESTS.

Test 207, Pennsylvania No. 4.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 30.4 per cent; ½ inch to 1 inch, 21 per cent; ¼ inch to ½ inch, 16.9 per cent; under ¼ inch, 31.7 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 208, Pennsylvania No. 4.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 25.8 per cent; ½ inch to 1 inch, 20.3 per cent; ¼ inch to ½ inch, 16.4 per cent; under ¼ inch, 37.5 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 209, Pennsylvania No. 4.

Size as shipped, over 1¼ inches. Size as used, over 1 inch, 30.7 per cent; ½ inch to 1 inch, 22.7 per cent; ¼ inch to ½ inch, 16.7 per cent; under ¼ inch, 29.9 per cent. Duration of test, 10.05 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 207.	Test 208.	Test 209.
Heating value of coal.....B. T. U. per pound dry coal..	13,979	13,921	13,952
Force of draft:			
Under stack damper.....inch water..	0.44	0.44	0.49
Above fire.....do....	.14	.13	.15
Furnace temperature.....°F..	2,363	2,223	2,200
Dry coal used per square foot of grate surface per hour.....pounds..	19.61	17.45	17.83
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.41	3.08	3.07
Percentage of rated horsepower of boiler developed.....	95.6	86.2	86.0
Water apparently evaporated per pound of coal as fired.....pounds..	8.10	8.23	8.02
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	9.47	9.62	9.38
Per pound of dry coal.....do....	9.70	9.84	9.61
Per pound of combustible.....do....	11.09	11.36	10.98
Efficiency of boiler, including grate.....per cent..	67.01	68.26	66.52
Coal as fired:			
Per indicated horsepower hour.....pounds..	2.99	2.94	3.01
Per electrical horsepower hour.....do....	3.69	3.63	3.72
Dry coal:			
Per indicated horsepower hour.....do....	2.92	2.87	2.94
Per electrical horsepower hour.....do....	3.60	3.55	3.63

ANALYSES.

	Test 207.	Test 208.	Test 209.		Test 207.	Test 208.	Test 209.
Proximate.				*Ultimate.*			
Moisture	2.32	2.22	2.34	Carbon [a]	77.48	77.21	77.40
Volatile matter	30.28	30.46	30.56	Hydrogen [a]	4.81	4.80	4.80
Fixed carbon	57.71	57.18	57.18	Oxygen [a]	5.03	4.98	5.02
Ash	9.69	10.14	9.92	Nitrogen [a]	1.48	1.48	1.49
	100.00	100.00	100.00	Sulphur	1.28	1.16	1.15
Sulphur	1.25	1.13	1.12	Ash	9.92	10.37	10.14
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 65, Pennsylvania No. 4.

Size as shipped, over 1¼ inches. Size as used, over 1¼ inches, 75 per cent; ½ inch to 1 inch, 9 per cent; ¼ inch to ½ inch, 6 per cent; under ¼ inch, 10 per cent. Duration of test, 50 hours.

Average electrical horsepower		195.1
Average B. T. U. gas, per cubic foot		140.6
Total coal fired	pounds	13,200

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR.)

	Test 65.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.42	1.40	1.24
Developed at switch board	1.35	1.33	1.18
Per brake horsepower:			
Available for outside purposes	1.21	1.19	1.05
Developed at engine	1.15	1.13	1.00
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.49	1.46	1.30
Developed at switch board	1.42	1.39	1.24
Per brake horsepower:			
Available for outside purposes	1.27	1.24	1.10
Developed at engine	1.21	1.18	1.05

ANALYSES.

	Test 65.		Test 65.
Coal.		*Gas by volume.*	
Moisture	1.79	Carbon dioxide (CO_2)	8.7
Volatile matter	30.17	Carbon monoxide (CO)	20.7
Fixed carbon	57.04	Hydrogen (H_2)	12.5
Ash	11.00	Methane (CH_4)	2.5
	100.00	Nitrogen (N_2)	55.6
Sulphur	1.35		100.0

PENNSYLVANIA NO. 5.

Bituminous coal from Nos. 1 and 2 mines, James W. Ellsworth & Co., Ellsworth, Washington County, Pa., on the Pennsylvania Railroad.

This sample consisted of "three-fourths inch coal" over a three-fourths inch bar screen. It was loaded under the supervision of Inspector W. J. Von Borries, and was used in making washing test No. 120, coking tests Nos. 25 and 26, steaming test No. 286, steaming tests on washed coal Nos. 194 and 195, and producer-gas test No. 59.

Two mine samples were taken for chemical analysis—No. 1966 from room 10 off the first butt entry, 3,000 feet southeast of the shaft in mine No. 2, and No. 1967 from room 17 off the fifth butt north entry, 3,000 feet north of the shaft in mine No. 1.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1966	1967	2068
Air-drying loss		1.50	1.50	1.00
Proximate.	Moisture	3.01	2.91	2.46
	Volatile matter	33.46	33.70	34.48
	Fixed carbon	58.70	57.99	57.01
	Ash	4.83	5.40	6.05
Ultimate.	Sulphur	.73	1.08	.88
	Hydrogen	.....	.....	5.26
	Carbon	.....	.....	77.99
	Nitrogen	.....	.....	1.53
	Oxygen	.....	.....	8.29
Calorific value determined:				
	Calories	7,887	.....	7,785
	British thermal units	14,197	.....	14,013

STEAMING TESTS.

Test 286, Pennsylvania No. 5.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 55.3 per cent; ½ inch to 1 inch, 14.5 per cent; ¼ inch to ½ inch, 9.8 per cent; ¼ inch, 20.4 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 194, Pennsylvania No. 5, washed.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 53.4 per cent; ½ inch to 1 inch, 22.2 per cent; ¼ inch to ½ inch, 11.8 per cent; under ¼ inch, 12.6, per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 195, Pennsylvania No. 5, washed.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 55.2 per cent; ½ inch to 1 inch, 18.7 per cent; ¼ inch to ½ inch, 11.8 per cent; under ¼ inch, 14.3 per cent. Duration of test, 10.02 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 286.	Test 194.	Test 195.
Heating value of coal.....B. T. U. per pound dry coal..	14,029	14,526	14,567
Force of draft:			
Under stack damper.....inch water..	0.36	0.51	0.47
Above fire.....do....	.12	.14	.16
Furnace temperature.....°F..	2,628	2,478	2,532
Dry coal used per square foot of grate surface per hour.....pounds..	18.43	20.52	19.97
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.42	3.53	3.46
Percentage of rated horsepower of boiler developed.....	95.9	98.8	96.9
Water apparently evaporated per pound of coal as fired.....pounds..	8.29	7.93	7.97

MISCELLANEOUS ITEMS—continued.

	Test 286.	Test 194.	Test 195.
Water evaporated from and at 212° F.:			
Per pound of coal as fired....pounds..	9.92	9.30	9.36
Per pound of dry coal....do....	10.35	9.59	9.65
Per pound of combustible....do....	11.40	10.21	10.36
Efficiency of boiler, including grate....per cent..	71.25	63.76	63.97
Coal as fired:			
Per indicated horsepower hour....pounds..	2.85	3.04	3.02
Per electrical horsepower hour....do....	3.52	3.75	3.73
Dry coal:			
Per indicated horsepower hour....do....	2.73	2.95	2.93
Per electrical horsepower hour....do....	3.37	3.64	3.62

ANALYSES.

	Test 286.	Test 194.	Test 195.		Test 286.	Test 194.	Test 195.
Proximate.				*Ultimate.*			
Moisture	4.11	3.03	2.97	Carbon[a]	78.03	80.86	81.04
Volatile matter	32.51	35.23	35.11	Hydrogen[a]	4.99	5.18	5.18
Fixed carbon	55.43	56.85	57.19	Oxygen[a]	6.11	6.34	6.34
Ash	7.95	4.89	4.73	Nitrogen[a]	1.53	1.59	1.59
	100.00	100.00	100.00	Sulphur	1.05	.99	.97
Sulphur	1.01	.96	.94	Ash	8.29	5.04	4.88
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 59, Pennsylvania No. 5.

Size as shipped, over ¾ inch. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	203.0
Average B. T. U. gas, per cubic foot	149.3
Total coal fired....pounds..	12,150

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 59.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.28	1.24	1.14
Developed at switch board	1.20	1.16	1.66
Per brake horsepower:			
Available for outside purposes	1.09	1.05	.97
Developed at engine	1.02	.98	.90
Equivalent used by producer plant.			
Per electrical horsepower.			
Available for outside purposes	1.37	1.32	1.21
Developed at switch board	1.28	1.24	1.14
Per brake horsepower:			
Available for outside purposes	1.16	1.12	1.03
Developed at engine	1.09	1.05	.97

ANALYSES.

	Test 59.		Test 59.
Coal.		*Gas by volume.*	
Moisture	3.42	Carbon dioxide (CO_2)	9.6
Volatile matter	32.73	Carbon monoxide (CO)	19.4
Fixed carbon	56.13	Hydrogen (H_2)	12.7
Ash	7.72	Methane (CH_4)	3.3
	100.00	Nitrogen (N_2)	55.0
Sulphur	.81		100.0

WASHING TEST.

Test 120, Pennsylvania No. 5.

Size as shipped, over ¾ inch. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	30,920
Washed coal	do....	29,000
Refuse	do....	1,920

ANALYSES.

	Test 120.	
	Raw coal.	Washed coal.
Moisture	2.46	4.91
Volatile matter	34.48	.....
Fixed carbon	57.01	.....
Ash	6.05	4.57
Sulphur	.88	.90

COKING TESTS.

Test 25, Pennsylvania No. 5.

Size as shipped, over ¾ inch. Size as used, finely crushed. Raw. Duration of test, 62 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,433
Breeze produced	do....	319
Coke produced	per cent..	61.94
Breeze produced	do....	2.66
Total percentage yield		64.60

Remarks.—Light-gray and silvery color. Foundry coke. Good, strong coke. High yield due to deposited carbon.

Test 26, Pennsylvania No. 5, washed.

Size as shipped, over ¾ inch. Size as used, finely crushed. Duration of test, 92 hours.

Coal charged	pounds..	13,000
Coke produced	do....	8,598
Breeze produced	do....	242
Coke produced	per cent..	66.14
Breeze produced	do....	1.86
Total percentage yield		68.00

Remarks.—Good, strong coke. Foundry coke Physical appearance not as good as coke from raw coal. Ash reduced by washing.

ANALYSES.

	Test 25.		Test 26.	
	Coal.	Coke.	Coal.	Coke.
Moisture	2.44	0.49	4.73	0.23
Volatile matter	34.28	.90	34.29	1.19
Fixed carbon	56.76	88.03	56.27	91.63
Ash	6.52	10.58	4.71	6.95
Sulphur	.97	.79	.94	.81

PENNSYLVANIA NO. 6.

Bituminous coal from Hustead-Seamens mine, Hustead-Seamens Coal and Coke Company East Millsboro, Westmoreland County, Pa., on the Pennsylvania Railroad.

This sample was run-of-mine coal and was loaded under the supervision of Inspector J. W. Groves. It was used in making washing test No. 124, coking tests Nos. 32, 34, 35, 38, and 41, steaming tests Nos. 217 and 218, and producer-gas tests Nos. 66 and 70.

Two mine samples were taken for chemical analysis. No. 1968 was cut from No. 5 butt entry, 900 feet from the bottom of the slope; No. 1970 was taken in No. 1 butt entry, 1,300 feet north of the bottom of the slope.

CHEMICAL ANALYSES.

		Mine samples.		Car samples.	
Laboratory number		1968	1970	2161	2176
Air-drying loss		2.90	1.50	2.00	2.40
Proximate.	Moisture	4.08	2.81	3.24	3.46
	Volatile matter	32.44	33.88	31.78	31.80
	Fixed carbon	53.98	54.68	52.46	51.74
	Ash	9.50	8.63	12.52	13.00
Ultimate.	Sulphur	1.64	2.00	1.94	1.95
	Hydrogen	.....	.....	4.80	.....
	Carbon	.....	.....	71.41	.....
	Nitrogen	.....	.....	1.24	1.20
	Oxygen	.....	.....	8.09	.....
Calorific value determined:					
Calories		7,371	.....	7,155	.....
British thermal units		13,268	.....	12,879	.....

STEAMING TESTS.

Test 217, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 35.4 per cent; ½ inch to 1 inch, 21.8 per cent; ¼ inch to ½ inch, 15 per cent; under ¼ inch, 27.8 per cent. Duration of test, 9.9 hours. Kind of grate, plain.

Test 218, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 26.4 per cent; ½ inch to 1 inch, 22.5 per cent; ¼ inch to ½ inch, 16.6 per cent; under ¼ inch, 34.5 per cent. Duration of test, 9.95 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 217.	Test 218.
Heating value of coal	B. T. U. per pound dry coal	13,405	13,271
Force of draft:			
Under stack damper	inch water	0.46	0.49
Above fire	do	.13	.17
Furnace temperature	°F	2,425	2,251
Dry coal used per square foot of grate surface per hour	pounds	19.26	16.65
Equivalent water evaporated per square foot of water-heating surface per hour, pounds		3.46	3.12
Percentage of rated horsepower of boiler developed		97.10	87.4
Water apparently evaporated per pound of coal as fired	pounds	7.46	7.74
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	8.79	9.11
Per pound of dry coal	do	9.01	9.37
Per pound of combustible	do	10.52	10.94
Efficiency of boiler, including grate	per cent	64.91	68.18

MISCELLANEOUS ITEMS—continued.

	Test 217.	Test 218.
Coal as fired:		
Per indicated horsepower hour.....pounds..	3.22	3.10
Per electrical horsepower hour.....do....	3.97	3.83
Dry coal:		
Per indicated horsepower hour.....do....	3.14	3.02
Per electrical horsepower hour.....do....	3.88	3.72

ANALYSES.

	Test 217.	Test 218.		Test 217.	Test 218.
Proximate.			*Ultimate.*		
Moisture	2.44	2.81	Carbon[a]	74.35	73.57
Volatile matter	32.98	32.80	Hydrogen[a]	4.62	4.58
Fixed carbon	52.48	51.72	Oxygen[a]	5.41	5.37
Ash	12.10	12.67	Nitrogen[a]	1.29	1.28
	100.00	100.00	Sulphur	1.93	2.16
Sulphur	1.88	2.10	Ash	12.40	13.04
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TESTS.

Test 66, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 45 per cent; ½ inch to 1 inch, 20 per cent; ¼ inch to ½ inch, 15 per cent; under ¼ inch, 20 per cent.
Duration of test, 47 hours.
Average electrical horsepower..... 195.3
Average B. T. U. gas, per cubic foot..... 126.6
Total coal fired.....pounds.. 13,000

Test 70, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, over 1 inch, 65 per cent; ½ inch to 1 inch, 16 per cent; ¼ inch to ½ inch, 7 per cent; under ¼ inch, 12 per cent.
Duration of test, 50 hours.
Average electrical horsepower..... 194.2
Average B. T. U. gas, per cubic foot..... 146.4
Total coal fired.....pounds.. 11,254

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 66.			Test 70.		
	Coal as fired.	Dry coal.	Combustible.	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:						
Available for outside purposes	1.53	1.50	1.38	1.23	1.19	1.05
Developed at switch board	1.42	1.39	1.28	1.16	1.13	.99
Per brake horsepower:						
Available for outside purposes	1.30	1.27	1.17	1.04	1.01	.89
Developed at engine	1.20	1.18	1.09	.99	.96	.84
Equivalent used by producer plant.						
Per electrical horsepower:						
Available for outside purposes	1.63	1.59	1.47	1.30	1.26	1.11
Developed at switch board	1.51	1.48	1.36	1.23	1.19	1.05
Per brake horsepower:						
Available for outside purposes	1.38	1.35	1.25	1.10	1.07	.94
Developed at engine	1.28	1.26	1.16	1.04	1.01	.89

ANALYSES.

	Test 66.	Test 70.		Test 66.	Test 70.
Coal.			*Gas by volume.*		
Moisture	2.15	2.86	Carbon dioxide (CO_2)	10.0	9.6
Volatile matter	35.01	31.88	Carbon monoxide (CO)	18.5	19.2
Fixed carbon	55.18	53.35	Hydrogen (H_2)	12.1	11.5
Ash	7.66	11.91	Methane (CH_4)	2.4	3.0
	100.00	100.00	Nitrogen (N_2)	57.0	56.7
Sulphur	1.60	2.04		100.00	100.00

WASHING TEST.

Test 124, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	50,000
Washed coal	do	43,300
Refuse	do	6,700

ANALYSES.

	Test 124.	
	Raw coal.	Washed coal.
Moisture	3.24	4.31
Volatile matter	31.78	.....
Fixed carbon	52.46	.....
Ash	12.52	7.26
Sulphur	1.94	1.47

COKING TESTS.

Test 32, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 46 hours.

Coal charged	pounds..	10,000
Coke produced	do....	7,330
Breeze produced	do....	315
Coke produced	per cent..	73.30
Breeze produced	do....	3.15
Total percentage yield		76.45

Remarks.—Very heavy coke. Silvery color. Much deposited carbon. Conditions of oven must have been practically perfect to attain these results.

Test 34, Pennsylvania No. 6, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 45 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,905
Breeze produced	do....	246
Coke produced	per cent..	69.05
Breeze produced	do....	2.46
Total percentage yield		71.51

Remarks.—Light-gray and silvery color. Heavy coke, but physically not as good as coke from raw coal. Ash and sulphur reduced by washing.

Test 35; Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 88 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,646
Breeze produced	do....	295
Coke produced	per cent..	72.05
Breeze produced	do....	2.46
Total percentage yield		74.51

Remarks.—Light-gray and silvery color. Good heavy coke. Sulphur and ash high.

Test 38, Pennsylvania No. 6, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 86 hours.

Coal charged	pounds..	13,000
Coke produced	do....	8,927
Breeze produced	do....	373
Coke produced	per cent..	68.67
Breeze produced	do....	2.87
Total percentage yield		71.54

Remarks.—Light gray and silvery. Not so good as coke from unwashed coal in physical appearance. Ash and sulphur reduced by washing.

Test 41, Pennsylvania No. 6.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 72 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,743
Breeze produced	do....	364
Coke produced	per cent..	72.86
Breeze produced	do....	3.03
Total percentage yield		75.89

Remarks.—Silvery color. Very heavy coke, but not dense. Breakage practically perfect, large pieces. Sulphur and ash high. High yield due to deposited carbon.

ANALYSES.

	Test 32.		Test 34.		Test 35.		Test 38.		Test 41.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	3.22	0.34	6.58	0.24	3.64	0.48	4.21	0.89	2.53	0.27
Volatile matter	31.52	.71	33.00	.66	32.01	1.62	33.40	2.26	32.09	1.26
Fixed carbon	51.87	82.31	52.96	88.61	51.03	81.20	55.21	86.77	53.21	82.66
Ash	13.39	16.64	7.46	10.49	13.32	16.70	7.18	10.08	12.17	15.81
Sulphur	2.10	1.59	1.46	1.21	1.93	1.70	1.51	1.24	1.78	1.52

PENNSYLVANIA NO. 7.

Bituminous coal from Ligonier mine, Old Colony Coal and Coke Company, 3 miles north of Ligonier, Westmoreland County, Pa., on the Ligonier Valley Railroad.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. S. Burrows. The following tests were made on it: Washing test No. 123, coking tests Nos. 30 and 33, steaming test No. 198, steaming test on washed coal No. 199, and producer-gas test No. 88.

Two mine samples were taken for chemical analysis —No. 1994 from room 3 off the fourth left head entry, 800 feet from drift mouth, and No. 1995 from room 3 off sixth right entry, 950 feet from drift mouth,

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1994	1995	2154
Air-drying loss		2.40	1.90	3.20
Proximate.	Moisture	3.30	2.78	4.09
	Volatile matter	23.03	22.91	20.62
	Fixed carbon	62.49	61.58	62.82
	Ash	11.18	12.73	12.47
	Sulphur	1.79	1.88	2.08
Ultimate.	Hydrogen	.....	.....	4.73
	Carbon	.....	.....	72.78
	Nitrogen	.....	.....	1.50
	Oxygen	.....	.....	6.44
Calorific value determined:				
	Calories	7,432	.....	7,307
	British thermal units	13,378	.....	13,153

STEAMING TESTS.

Test 198, Pennsylvania No. 7.

Size as shipped, run of mine. Size as used, over 1 inch, 13.4 per cent; ½ inch to 1 inch, 16.7 per cent; ¼ inch to ½ inch, 18.9 per cent; under ¼ inch, 51.0 per cent. Duration of test, 10.03 hours. Kind of grate, plain.

Test 199, Pennsylvania No. 7, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 19.2 per cent; ½ inch to 1 inch, 22.0 per cent; ¼ inch to ½ inch, 20.4 per cent; under ¼ inch, 38.4 per cent. Duration of test, 10.03 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 198.	Test 199.
Heating value of coal	B. T. U. per pound dry coal	13,648	13,828
Force of draft:			
Under stack damper	inch water	0.48	0.39
Above fire	do	.16	.12
Furnace temperature	°F.	2,091	2,230
Dry coal used per square foot of grate surface per hour	pounds	17.04	16.74
Equivalent water evaporated per square foot of water-heating surface per hour	pounds	3.12	3.16
Percentage of rated horsepower of boiler developed		87.5	88.6
Water apparently evaporated per pound of coal as fired	pounds	7.55	7.64
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	8.87	8.99
Per pound of dry coal	do	9.18	9.44
Per pound of combustible	do	10.85	10.88
Efficiency of boiler, including grate	per cent	64.96	65.93
Coal as fired:			
Per indicated horsepower hour	pounds	3.19	3.15
Per electrical horsepower hour	do	3.94	3.88
Dry coal:			
Per indicated horsepower hour	do	3.08	3.00
Per electrical horsepower hour	do	3.80	3.70

ANALYSES.

	Test 198.	Test 199.		Test 198.	Test 199.
Proximate.			*Ultimate.*		
Moisture	3.45	4.80	Carbon[a]	75.36	77.64
Volatile matter	21.79	22.64	Hydrogen[a]	4.42	4.56
Fixed carbon	62.20	61.62	Oxygen[a]	2.93	3.00
Ash	12.56	10.94	Nitrogen[a]	1.55	1.60
	100.00	100.00	Sulphur	2.73	1.70
Sulphur	2.63	1.62	Ash	13.01	11.50
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 88, Pennsylvania No. 7.

Size as shipped, run of mine. Size as used, over 1 inch, 41 per cent; ½ inch to 1 inch, 16 per cent; ¼ inch to ½ inch, 15 per cent; under ¼ inch, 28 per cent. Duration of test, 50 hours.

Average electrical horsepower 169.9
Average B. T. U. gas, per cubic foot 139.4
Total coal fired ..... pounds.. 13,350

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 88.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.68	1.62	1.41
Developed at switch board	1.57	1.52	1.32
Per brake horsepower:			
Available for outside purposes	1.42	1.37	1.19
Developed at engine	1.34	1.29	1.12
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.79	1.72	1.50
Developed at switch board	1.68	1.62	1.41
Per brake horsepower:			
Available for outside purposes	1.52	1.47	1.27
Developed at engine	1.42	1.37	1.19

ANALYSES.

	Test 88.		Test 88.
Coal.		*Gas by volume.*	
Moisture	3.52	Carbon dioxide (CO_2)	10.2
Volatile matter	22.25	Carbon monoxide (CO)	17.5
Fixed carbon	61.57	Hydrogen (H_2)	11.3
Ash	12.66	Methane (CH_4)	2.5
	100.00	Nitrogen (N_2)	58.5
Sulphur	1.99		100.00

WASHING TEST.

Test 123, Pennsylvania No. 7.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	32,000
Washed coal	do....	27,180
Refuse	do....	4,820

ANALYSES.

	Test 123.	
	Raw coal.	Washed coal.
Moisture	4.09	5.67
Volatile matter	20.62	.....
Fixed carbon	62.82	.....
Ash	12.47	10.08
Sulphur	2.08	1.55

COKING TESTS.

Test 30, Pennsylvania No. 7.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 90 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,750
Breeze produced	do....	325
Coke produced	per cent..	72.92
Breeze produced	do....	2.71
Total percentage yield		75.63

Remarks.—Gray color. Heavy coke. High ash and sulphur.

Test 33, Pennsylvania No. 7, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 93 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,400
Breeze produced	do....	509
Coke produced	per cent..	70.00
Breeze produced	do....	4.24
Total percentage yield		74.24

Remarks.—Gray color. Heavy coke. Very little improved by washing.

ANALYSES.

	Test 30.		Test 33.	
	Coal.	Coke.	Coal.	Coke.
Moisture	3.75	0.46	3.98	0.43
Volatile matter	21.89	1.16	23.32	1.84
Fixed carbon	62.04	82.39	60.75	83.40
Ash	12.32	15.99	11.95	14.33
Sulphur	2.33	1.87	1.64	1.42

PENNSYLVANIA NO. 8.

Bituminous coal from mine No. 3, Pennsylvania Coal and Coke Company, Ehrenfeld, Cambria County, Pa., on the Pennsylvania Railroad.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. S. Burrows. The following tests were made on it: Coking test No. 29, steaming test Nos. 236, 237, 238, and 239, steaming test on dried coal No. 242, and producer-gas test No. 63. A steaming test (No. 245) was also made on this sample, mixed with Virginia No. 4.

Two samples for chemical analysis were taken from this mine—No. 2014 from the *twenty-third* head entry, 2¼ miles from the drift mouth, and No. 2015 from the face of the *main entry, 2¾ miles from* the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2014	2015	2152
Air-drying loss		2.80	2.20	2.90
Proximate.	Moisture	3.49	3.09	3.51
	Volatile matter	16.12	16.66	16.82
	Fixed carbon	74.68	74.79	73.04
	Ash	5.71	5.46	6.63
	Sulphur	.95	1.18	.94
Ultimate.	Hydrogen	.....	.....	4.56
	Carbon	.....	.....	80.70
	Nitrogen	.....	.....	1.26
	Oxygen	.....	.....	5.91
Calorific value determined:				
	Calories	8,064	.....	7,933
	British thermal units	14,515	.....	14,279

STEAMING TESTS.

Test 236, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 6.5 per cent; ½ inch to 1 inch, 13.6 per cent; ¼ inch to ½ inch, 22.4 per cent; under ¼ inch, 57.5 per cent. Duration of test, 9.88 hours. Kind of grate, rocking.

Test 237, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 5.8 per cent; ½ inch to 1 inch, 12.3 per cent; ¼ inch to ½ inch, 19.5 per cent; under ¼ inch, 62.4 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 238, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 5.4 per cent; ½ inch to 1 inch, 9.1 per cent; ¼ inch to ½ inch, 14.9 per cent; under ¼ inch, 70.6 per cent. Duration of test, 10.02 hours. Kind of grate, rocking.

Test 239, Pennsylvania No. 8.

Size as shipped, run of mine Size as used, over 1 inch, 4.4 per cent; ½ inch to 1 inch, 8.8 per cent; ¼ inch to ½ inch, 16.2 per cent; under ¼ inch, 70.6 per cent. Duration of test, 9.92 hours. Kind of grate, rocking.

Test 242, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, over 1 inch, 2.0 per cent; ½ inch to 1 inch, 7.0 per cent; ¼ inch to ½ inch, 14.5 per cent; under ¼ inch, 76.5 per cent. Dried coal. Duration of test, 7.88 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 236.	Test 237.	Test 238.	Test 239.	Test 242.
Heating value of coal B. T. U. per pound dry coal	14,886	14,868	14,828	14,690	14,659
Force of draft:					
Under stack damper, inch water	0.43	0.45	0.50	0.63	0.47
Above fire, do	.15	.16	.17	.19	.16
Furnace temperature, °F	2,317	2,266	2,212	.....	2,059
Dry coal used per square foot of grate surface per hour, pounds	15.74	16.23	15.69	17.64	14.33
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	2.93	2.96	2.93	3.08	2.92
Percentage of rated horsepower of boiler developed	82.0	83.0	82.1	86.5	81.9
Water apparently evaporated per pound of coal as fired, pounds	8.51	8.27	8.44	7.98	8.52
Water evaporated from and at 212° F.:					
Per pound of coal as fired, do	10.12	9.85	10.05	9.52	10.17
Per pound of dry coal, do	10.37	10.17	10.42	9.75	10.22
Per pound of combustible, do	11.20	11.02	11.29	10.71	11.15
Efficiency of boiler, including grate, per cent	67.27	66.06	67.86	64.10	67.19

MISCELLANEOUS ITEMS—continued.

	Test 236.	Test 237.	Test 238.	Test 239.	Test 242.
Coal as fired:					
Per indicated horsepower hour.....pounds.	2.79	2.87	2.81	2.97	2.78
Per electrical horsepower hour.....do....	3.45	3.54	3.47	3.67	3.43
Dry coal:					
Per indicated horsepower hour.....do....	2.73	2.78	2.71	2.90	2.77
Per electrical horsepower hour.....do....	3.37	3.43	3.35	3.58	3.41

ANALYSES.

	Test 236.	Test 237.	Test 238.	Test 239.	Test 242.
Proximate.					
Moisture	2.37	3.11	3.56	2.44	0.42
Volatile matter	16.74	15.68	16.09	16.64	17.51
Fixed carbon	74.66	74.93	73.85	73.69	75.20
Ash	6.23	6.28	6.50	7.23	6.87
	100.00	100.00	100.00	100.00	100.00
Sulphur	.88	.89	.87	1.12	1.01
Ultimate.					
Carbon[a]	84.14	84.03	83.81	82.98	83.35
Hydrogen[a]	4.34	4.35	4.33	4.28	4.15
Oxygen[a]	2.93	2.91	2.91	2.89	3.27
Nitrogen[a]	1.31	1.31	1.31	1.29	1.32
Sulphur	.90	.92	.90	1.15	1.01
Ash	6.38	6.48	6.74	7.41	6.90
	100.00	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 63, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	187.9
Average B. T. U. gas, per cubic foot	133.0
Total coal fired.....pounds..	11,100

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 63.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.25	1.22	1.13
Developed at switch board	1.18	1.15	1.07
Per brake horsepower:			
Available for outside purposes	1.06	1.04	.96
Developed at engine	1.00	.98	.91
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.35	1.32	1.22
Developed at switch board	1.28	1.25	1.15
Per brake horsepower:			
Available for outside purposes	1.15	1.12	1.04
Developed at engine	1.09	1.06	.98

ANALYSES.

	Test 63.		Test 63.
Coal.		*Gas by volume.*	
Moisture	2.49	Carbon dioxide (CO_2)	9.9
Volatile matter	16.61	Carbon monoxide (CO)	18.7
Fixed carbon	73.70	Hydrogen (H_2)	14.1
Ash	7.20	Methane (CH_4)	2.2
	100.00	Nitrogen (N_2)	55.1
Sulphur	.91		100.0

COKING TEST.

Test 29, Pennsylvania No. 8.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 51 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,223
Breeze produced	do....	1,600
Coke produced	per cent..	52.23
Breeze produced	do....	16.00
Total percentage yield		68.23

Remarks.—Soft, dense coke. Dull-gray color. Large and small chunks. Heavy black butt on coke. Hard to burn.

ANALYSES.

	Test 29.	
	Coal.	Coke.
Moisture	3.32	0.91
Volatile matter	15.56	2.16
Fixed carbon	74.29	88.99
Ash	6.83	7.94
Sulphur	1.12	.91

PENNSYLVANIA NO. 9.

Bituminous coal from Kimmelton mine, Reading Iron Company, Kimmelton, Somerset County, Pa., on the Baltimore and Ohio Railroad.

This sample, which was loaded under the supervision of Inspector W. J. Von Borries, consisted of run-of-mine coal, and was used in making washing test No. 126 and coking tests Nos. 37, 39, 42, and 56.

Two mine samples were taken for chemical analysis, as follows: No. 2016 from the second head entry off the sixth right entry, 3,200 feet south of the drift mouth, and No. 2017 from the eighth left entry, 3,000 feet southeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2016	2017	2199
Air-drying loss		1.80	3.20	2.60
Proximate.	Moisture	2.63	3.90	3.09
	Volatile matter	16.22	14.64	17.29
	Fixed carbon	70.94	73.13	68.29
	Ash	10.21	8.33	11.33
Ultimate.	Sulphur	2.05	1.76	2.04
	Hydrogen	.....	.....	4.19
	Carbon	.....	.....	75.40
	Nitrogen	.....	.....	1.25
	Oxygen	.....	.....	5.79
Calorific value determined:				
	Calories	7,614	.....	7,458
	British thermal units	13,705	.....	13,424

WASHING TEST.

Test 126, Pennsylvania No. 9.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	12,000
Washed coal	do....	9,700
Refuse	do....	2,300

ANALYSES.

	Test 126.	
	Raw coal.	Washed coal.
Moisture	3.09	4.58
Volatile matter	17.29	.....
Fixed carbon	68.29	.....
Ash	11.33	8.75
Sulphur	2.04	1.24

COKING TESTS.

Test 37, Pennsylvania No. 9.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 45 hours.

Coal charged	pounds..	7,000
Coke produced, few pieces.		

Remarks.—Few pieces of dull coke obtained, and analysis was made from these. The amount was too small to calculate as percentage yield of coke.

Test 39, Pennsylvania No. 9.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 66 hours.

Coal charged	pounds..	8,000
Coke produced, few pieces.		

Remarks.—This was the second test on this coal and a few pieces were obtained. Result warranted another trial after washing.

Test 42, Pennsylvania No. 9, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 51 hours.

Coal charged	pounds..	8,000
Coke produced	do....	5,600
Breeze produced	do....	801
Coke produced	per cent..	70.00
Breeze produced	do....	10.01
Total percentage yield		80.01

Remarks.—This was the third trial on this coal. The other two charges were raw, and succeeded in getting only a few pieces of coke. Washing reduced sulphur and ash. Coke was dull-gray in color. Breaks badly into small pieces, and breeze content very large.

Test 56, Pennsylvania No. 9.

Size as shipped, run of mine. Size as used, finely crushed. Raw, with 5 per cent pitch. Duration of test, 38 hours.

Coal charged	pounds..	8,000
Coke produced	do....	5,300
Breeze produced	do....	495
Coke produced	per cent..	66.25
Breeze produced	do....	6.19
Total percentage yield		72.44

Remarks.—Dull-gray color. Poor soft coke. Quality not so good as coke from washed coal. Ash and sulphur higher.

ANALYSES.

	Test 37.		Test 39.	Test 42.		Test 56.	
	Coal.	Coke.	Coal.	Coal.	Coke.	Coal.	Coke.
Moisture	3.26	0.70	2.86	4.55	0.54	2.60	0.72
Volatile matter	16.18	1.05	16.24	17.59	1.21	17.92	.61
Fixed carbon	69.44	84.92	68.60	68.80	86.84	69.36	86.02
Ash	11.12	13.33	12.30	9.06	11.41	10.12	12.65
Sulphur	1.90	1.53	2.14	1.39	1.06	1.80	1.53

PENNSYLVANIA NO. 10.

Bituminous coal from Bertha mine, Pittsburg-Buffalo Coal Company, Bruce, Allegheny County, Pa., on the Baltimore and Ohio Railroad.

This sample consisted of "three-fourths inch coal." It was loaded under the supervision of Inspector W. J. Von Borries, and was used in making coking tests Nos. 47 and 53, steaming tests Nos. 227, 228, and 229, and producer-gas test No. 71.

Two mine samples were taken for chemical analysis, as follows: No. 2080 from No 1 face entry off No. 1 butt entry, 5,000 feet from the drift mouth, and No. 2081 from the third face entry, 300 feet from the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2080	2081	2229
Air-drying loss		1.80	2.20	1.30
Proximate.	Moisture	3.67	4.08	2.61
	Volatile matter	34.03	34.41	34.92
	Fixed carbon	56.84	56.19	56.30
	Ash	5.46	5.32	6.17
Ultimate.	Sulphur	1.37	1.31	1.26
	Hydrogen	.....	.....	5.21
	Carbon	.....	.....	77.14
	Nitrogen	.....	.....	1.57
	Oxygen	.....	.....	8.65
Calorific value determined:				
	Calories	7,708	.....	7,776
	British thermal units	13,874	.....	13,997

STEAMING TESTS.

Test 227, Pennsylvania No. 10.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 22.8 per cent; ½ inch to 1 inch, 23.2 per cent; ¼ inch to ½ inch, 18.5 per cent; under ¼ inch, 35.5 per cent. Duration of test, 10.0 hours. Kind of grate, rocking.

Test 228, Pennsylvania No. 10.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 23.9 per cent; ½ inch to 1 inch, 18.7 per cent; ¼ inch to ½ inch, 15.8 per cent; under ¼ inch, 41.6 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

Test 229, Pennsylvania No. 10.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 27.4 per cent; ½ inch to 1 inch, 21.7 per cent; ¼ inch to ½ inch, 16.7 per cent; under ¼ inch, 34.2 per cent. Duration of test, 10.0 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 227.	Test 228.	Test 229.
Heating value of coal.....B. T. U. per pound dry coal..	14,341	14,324	14,431
Force of draft:			
Under stack damper.....inch water..	0.52	0.48	0.56
Above fire.....do....	.16	.16	.15
Furnace temperature.....°F..	.....	2,329	2,445
Dry coal used per square foot of grate surface per hour.....pounds..	19.07	17.80	21.73
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.46	3.23	3.78
Percentage of rated horsepower of boiler developed.....	97.0	90.7	105.9
Water apparently evaporated per pound of coal as fired.....pounds..	8.28	8.35	7.94
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	9.80	9.85	9.47
Per pound of dry coal.....do....	10.12	10.14	9.69
Per pound of combustible.....do....	11.03	11.09	10.49
Efficiency of boiler, including grate.....per cent..	68.15	68.36	64.84
Coal as fired:			
Per indicated horsepower hour.....pounds..	2.89	2.87	2.99
Per electrical horsepower hour.....do....	3.56	3.55	3.69
Dry coal:			
Per indicated horsepower hour.....do....	2.79	2.79	2.92
Per electrical horsepower hour.....do....	3.45	3.44	3.61

ANALYSES.

	Test 227.	Test 228.	Test 229.		Test 227.	Test 228.	Test 229.
Proximate.				*Ultimate.*			
Moisture	3.13	2.88	2.29	Carbon [a]	79.03	78.92	79.53
Volatile matter	34.84	34.76	35.93	Hydrogen [a]	5.05	5.04	5.08
Fixed carbon	55.75	55.98	55.87	Oxygen [a]	6.46	6.47	6.51
Ash	6.28	6.38	5.91	Nitrogen [a]	1.61	1.61	1.62
	100.00	100.00	100.00	Sulphur	1.37	1.39	1.21
Sulphur	1.33	1.35	1.18	Ash	6.48	6.57	6.05
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 71, Pennsylvania No. 10.

Size as shipped, over ¾ inch. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	196.3
Average B. T. U. gas, per cubic foot	159.5
Total coal fired, pounds	12,300

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 71.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.32	1.28	1.17
Developed at switch board	1.25	1.22	1.11
Per brake horsepower:			
Available for outside purposes	1.12	1.09	0.99
Developed at engine	1.07	1.04	0.95
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.38	1.35	1.23
Developed at switch board	1.32	1.28	1.17
Per brake horsepower:			
Available for outside purposes	1.18	1.14	1.04
Developed at engine	1.12	1.09	0.99

ANALYSES.

	Test 71.		Test 71.
Coal.		*Gas by volume.*	
Moisture	2.77	Carbon dioxide (CO_2)	9.2
Volatile matter	33.94	Carbon monoxide (CO)	20.4
Fixed carbon	54.84	Hydrogen (H_2)	13.8
Ash	8.45	Methane (CH_4)	3.4
	100.00	Nitrogen (N_2)	53.2
Sulphur	1.37		100.0

COKING TESTS.

Test 47, Pennsylvania No. 10.

Size as shipped, ¼ inch. Size as used, not crushed. Raw. Duration of test, 49 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,400
Breeze produced	do....	340
Coke produced	per cent..	61.67
Breeze produced	do....	2.83
Total percentage yield		64.50

Remarks.—Light-gray and silvery color. Somewhat brittle. Large-cell structure. Good furnace coke.

Test 53, Pennsylvania No. 10.

Size as shipped, over ¼ inch. Size as used, finely crushed. Raw. Duration of test, 47 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,322
Breeze produced	do....	268
Coke produced	per cent..	69.35
Breeze produced	do....	2.23
Total percentage yield		71.58

Remarks.—Light gray and silvery. Breakage poor; small pieces. Good furnace coke. High yield due to deposited carbon.

ANALYSES.

	Test 47.		Test 53.	
	Coal.	Coke.	Coal.	Coke.
Moisture	2.56	0.39	2.73	0.36
Volatile matter	34.80	1.14	35.41	1.14
Fixed carbon	56.81	90.40	55.58	89.93
Ash	5.83	8.07	6.28	8.57
Sulphur	1.25	1.00	1.36	1.05

VIRGINIA NO. 1.

Bituminous coal from H. C. Morris prospect, Interstate Investment Company, Crab Orchard, Lee County, Va., about 7 miles from the Louisville and Nashville Railroad.

This sample, which might be designated run-of-mine coal, was taken from a small prospect hole or country bank and was hauled in wagons, under the supervision of Inspector J. S. Burrows, to the railroad. It was used in making coking tests Nos. 64, 65, 67, 68, and 77, steaming tests Nos. 281 and 282, and producer-gas test No. 77.

Three mine samples were taken for chemical analysis at this point. No. 2246 was cut from the entire seam of the left rib of the drift, 29 feet from the outcrop; No. 2268 was cut from the lower bench at the face of the drift; No. 2269 was cut from the upper bench at the face of the drift.

CHEMICAL ANALYSES.

		Mine samples.			Car sample.
Laboratory number		2246	2268	2269	2420
Air-drying loss		2.60	4.20	4.40	2.40
Proximate.	Moisture	4.72	5.69	6.55	4.06
	Volatile matter	34.21	34.43	33.51	34.93
	Fixed carbon	56.44	51.77	55.54	56.28
	Ash	4.63	8.11	4.40	4.73
Ultimate.	Sulphur	2.55	2.31	.80	1.20
	Hydrogen				5.32
	Carbon				76.59
	Nitrogen				1.24
	Oxygen				10.92
Calorific value determined:					
	Calories		7,287		7,681
	British thermal units		13,117		13,826

STEAMING TESTS.

Test 281, Virginia No. 1.

Size as shipped, run of mine. Size as used, over 1 inch, 30 per cent; ½ inch to 1 inch, 21.3 per cent; ¼ inch to ½ inch, 17.5 per cent; under ¼ inch, 31.2 per cent. Duration of test, 9.75 hours. Kind of grate, rocking.

Test 282, Virginia No. 1.

Size as shipped, run of mine. Size as used, over 1 inch, 25.4 per cent; ½ inch to 1 inch, 21.6 per cent; ¼ inch to ½ inch, 19.4 per cent; under ¼ inch, 33.6 per cent. Duration of test, 9.83 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 281.	Test 282.
Heating value of coal.....B. T. U. per pound dry coal..	14,281	14,198
Force of draft:		
Under stack damper.....inch water..	0.41	0.38
Above fire.....do....	.14	.11
Furnace temperature.....°F..	2,637	2,542
Dry coal used per square foot of grate surface per hour.....pounds..	18.35	18.57
Equivalent water evaporated per square foot of water-heating surface per hour, pounds.....	3.29	3.29
Percentage of rated horsepower of boiler developed.....	92.2	92.3
Water apparently evaporated per pound of coal as fired.....pounds..	7.95	7.82
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	9.54	9.39
Per pound of dry coal.....do....	10.01	9.89
Per pound of combustible.....do....	10.78	10.72
Efficiency of boiler, including grate.....per cent..	67.69	67.27
Coal as fired:		
Per indicated horsepower hour.....pounds..	2.96	3.01
Per electrical horsepower hour.....do....	3.66	3.72
Dry coal:		
Per indicated horsepower hour.....do....	2.82	2.86
Per electrical horsepower hour.....do....	3.49	3.53

ANALYSES.

	Test 281.	Test 282.		Test 281.	Test 282.
Proximate.			*Ultimate.*		
Moisture	4.62	5.05	Carbon[a]	79.12	78.67
Volatile matter	33.85	32.82	Hydrogen[a]	5.03	5.00
Fixed carbon	55.92	56.05	Oxygen[a]	7.56	7.50
Ash	5.61	6.08	Nitrogen[a]	1.28	1.28
	100.00	100.00	Sulphur	1.13	1.15
Sulphur	1.08	1.09	Ash	5.88	6.40
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 77, Virginia No. 1.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	196.2
Average B. T. U. gas, per cubic foot	164.4
Total coal fired, pounds	14,100

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 77.		
	Coal as fired.	Drycoal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.51	1.43	1.33
Developed at switch board	1.44	1.35	1.26
Per brake horsepower:			
Available for outside purposes	1.29	1.21	1.13
Developed at engine	1.22	1.15	1.07
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.61	1.52	1.42
Developed at switch board	1.53	1.44	1.34
Per brake horsepower:			
Available for outside purposes	1.37	1.29	1.20
Developed at engine	1.30	1.23	1.14

ANALYSES.

	Test 77.		Test 77.
Coal.		*Gas by volume.*	
Moisture	5.72	Carbon dioxide (CO_2)	10.0
Volatile matter	31.93	Carbon monoxide (CO)	19.7
Fixed carbon	55.91	Hydrogen (H_2)	14.0
Ash	6.44	Methane (CH_4)	3.6
	100.00	Nitrogen (N_2)	51.8
Sulphur	1.08		100.0

COKING TESTS.

Test 64, Virginia No. 1.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 71 hours.

Coal charged	pounds..	14,000
Coke produced	do....	9,079
Breeze produced	do....	415
Coke produced	per cent..	64.85
Breeze produced	do....	2.96
Total percentage yield		67.81

Remarks.—Light gray. Hard heavy coke. High yield due to deposited carbon.

Test 65, Virginia No. 1.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 36 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,811
Breeze produced	do....	258
Coke produced	per cent..	68.11
Breeze produced	do....	2.58
Total percentage yield		70.69

Remarks.—Light gray and silvery. Good heavy coke. High yield due to deposited carbon.

Test 67, Virginia No. 1.

Size as shipped, run of mine. Size as used, not crushed. Raw. Duration of test, 36 hours.

Coal charged	pounds..	10,000
Coke produced	do....	5,879
Breeze produced	do....	424
Coke produced	per cent..	58.79
Breeze produced	do....	4.24
Total percentage yield		63.03

Remarks.—Light gray and silvery. Coke not so good as that from ground charge. Cross breakage increased and breeze much larger, but good coke. Results would justify installation of disintegrating machinery. High yield due to deposited carbon.

Test 68, Virginia No. 1.

Size as shipped, run of mine. Size as used not crushed. Raw. Duration of test, 67 hours.

Coal charged	pounds..	14,000
Coke produced	do....	8,596
Breeze produced	do....	590
Coke produced	per cent..	61.40
Breeze produced	do....	4.21
Total percentage yield		65.61

Remarks.—Light gray and silvery. Large percentage of breeze due to not grinding coal before charging. Loss by breakage also increased from same cause. Good hard heavy coke. High yield due to deposited carbon.

Test 77, Virginia No. 1.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 65 hours.

Coal charged	pounds..	14,000
Coke produced	do....	9,506
Breeze produced	do....	314
Coke produced	per cent..	67.90
Breeze produced	do....	2.24
Total percentage yield		70.14

Remarks.—Light gray and silvery. Good hard heavy coke. High yield due to deposited carbon.

ANALYSES.

	Test 64.		Test 65.		Test 67.		Test 68.		Test 77.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	5.70	1.52	4.44	1.23	4.95	0.21	4.82	0.30	4.40	0.20
Volatile matter	32.52	.99	33.44	1.67	34.21	.89	33.21	1.16	35.09	.80
Fixed carbon	56.15	89.20	56.27	89.24	55.86	90.99	56.95	90.85	55.24	91.52
Ash	5.63	8.29	5.85	7.86	4.98	7.91	5.02	7.69	5.27	7.48
Sulphur	.98	.88	1.13	.94	1.12	1.01	1.10	.97	1.05	1.02

VIRGINIA NO. 2.

Bituminous coal from the "big opening" on Wilson farm, Interstate Investment Company, near Crab Orchard, Lee County, Va., about 7 miles from the Louisville and Nashville Railroad.

This sample, which was run of mine, was loaded in wagons and hauled to the railroad under the supervision of Inspector J. S. Burrows. It was used for washing test No. 134, coking tests Nos. 63, 69, and 70; steaming tests Nos. 247, 251, 256, and 258, steaming test on washed coal No. 260, and producer-gas test No. 78.

Two mine samples were taken in this opening for chemical analysis. No. 2248 was taken from the upper bench at the face of the opening, 75 feet from the outcrop; No. 2249 was taken from the lower bench at the same location.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2248	2249	2476
Air-drying loss		1.90	5.00	1.90
Proximate.	Moisture	3.90	6.80	3.35
	Volatile matter	34.08	33.01	35.13
	Fixed carbon	56.96	58.26	55.94
	Ash	5.06	1.93	5.58
Ultimate.	Sulphur	.90	.68	.92
	Hydrogen			5.19
	Carbon			77.02
	Nitrogen			1.42
	Oxygen			9.87
Calorific value determined:				
	Calories			7,740
	British thermal units			13,932

STEAMING TESTS.

Test 247, Virginia No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 49.6 per cent; ½ inch to 1 inch, 23 per cent; ¼ inch to ½ inch, 12.4 per cent; under ¼ inch, 15 per cent. Duration of test, 8 hours. Kind of grate, plain.

Test 251, Virginia No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 45 per cent, ½ inch to 1 inch, 18 per cent; ¼ inch to ½ inch, 13.4 per cent, under ¼ inch 23.6 per cent. Duration of test, 8 hours. Kind of grate, plain.

Test 256, Virginia No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 28.9 per cent, ½ inch to 1 inch, 18.9 per cent; ¼ inch to ½ inch, 15 per cent, under ¼ inch. 37.2 per cent. Duration of test, 8.43 hours. Kind of grate, rocking.

Test 258, Virginia No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 31.8 per cent; ½ inch to 1 inch, 19 per cent; ¼ inch to ½ inch, 16.9 per cent; under ¼ inch, 32.3 per cent. Test run on an ordinary Frost fire-tube boiler. Duration of test, 7 hours. Kind of grate, rocking.

Test 260, Virginia No. 2, washed.

Size as shipped, run of mine. Size as used, over 1 inch 49.5 per cent; ½ inch to 1 inch, 23.3 per cent, ¼ inch to ½ inch, 12.6 per cent; under ¼ inch, 14.6 per cent. Duration of test, 9.87 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 247.	Test 251.	Test 256.	Test 258.	Test 260.
Heating value of coal..B. T. U. per pound dry coal..	14,443	14,285	14,317	14,254	14,497
Force of draft:					
Under stack damper.....inch water..	0.44	0.41	0.44	0.23	0.34
Above fire.....do....	.10	.10	.15	.20	.13
Furnace temperature.....°F..	2,548	2,515	2,673	(a)	2,671
Dry coal used per square foot of grate surface per hour.....pounds..	18.52	17.71	18.24	.....	18.02
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.71	3.41	3.13	.....	3.13
Percentage of rated horsepower of boiler developed..	104.0	95.60	87.6	b 110.0	87.7
Water apparently evaporated per pound of coal as fired.....pounds..	8.21	7.82	7.67	6.96	7.79
Water evaporated from and at 212° F.:					
Per pound of coal as fired.....do....	9.76	9.32	9.16	8.26	9.35
Per pound of dry coal.....do....	10.02	9.65	9.56	8.57	9.68
Per pound of combustible.....do....	10.74	10.45	10.45	9.45	10.38
Efficiency of boiler, including grate.....per cent..	67.00	65.24	64.48	58.06	64.48
Coal as fired:					
Per indicated horsepower hour.....pounds...	2.90	3.03	3.09	3.42	3.02
Per electrical horsepower hour.....do....	3.58	3.75	3.81	4.23	3.73
Dry coal:					
Per indicated horsepower hour.....do....	2.82	2.93	2.96	3.30	2.92
Per electrical horsepower hour.....do....	3.48	3.62	3.65	4.07	3.61

a Too low for pyrometer. b Approximately.

ANALYSES.

	Test 247.	Test 251.	Test 256.	Test 258.	Test 260.
Proximate.					
Moisture	2.56	3.37	4.22	3.60	3.34
Volatile matter	35.34	33.75	33.48	33.56	36.14
Fixed carbon	56.72	56.41	56.11	56.23	56.04
Ash	5.38	6.47	6.19	6.61	4.48
	100.00	100.00	100.00	100.00	100.00
Sulphur	.98	.82	.82	.85	.85
Ultimate.					
Carbon a	79.86	79.00	79.18	78.82	80.74
Hydrogen a	5.01	4.95	4.96	4.94	5.05
Oxygen a	7.12	7.04	7.08	7.05	7.21
Nitrogen a	1.48	1.46	1.46	1.45	1.49
Sulphur	1.01	.85	.86	.88	.88
Ash	5.52	6.70	6.46	6.86	4.63
	100.00	100.00	100.00	100.00	100.00

a Figured from car sample.

PRODUCER-GAS TEST.

Test 78, Virginia No. 2.

Size as shipped, run of mine. Size as used, over 1 inch, 74 per cent; ½ inch to 1 inch 11 per cent; ¼ inch to ½ inch, 6 per cent; under ¼ inch, 9 per cent. Duration of test, 50 hours.

Average electrical horsepower	197.5
Average B. T. U. gas, per cubic foot	169.0
Total coal fired, pounds	12,950

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 78.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.39	1.36	1.26
Developed at switch board	1.31	1.28	1.20
Per brake horsepower:			
Available for outside purposes	1.18	1.15	1.09
Developed at engine	1.11	1.09	1.02
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.47	1.43	1.35
Developed at switch board	1.38	1.35	1.27
Per brake horsepower:			
Available for outside purposes	1.25	1.22	1.14
Developed at engine	1.17	1.15	1.08

ANALYSES.

	Test 78.		Test 78.
Coal.		*Gas by volume.*	
Moisture	2.36	Carbon dioxide (CO_2)	8.2
Volatile matter	36.40	Carbon monoxide (CO)	22.3
Fixed carbon	55.44	Hydrogen (H_2)	13.0
Ash	5.80	Methane (CH_4)	3.5
	100.00	Nitrogen (N_2)	53.0
Sulphur	.67		100.0

WASHING TEST.

Test 134, Virginia No. 2.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	28,000
Washed coal	do	24,550
Refuse	do	3,450

ANALYSES.

	Test 134.	
	Raw coal.	Washed coal.
Moisture	3.35	6.39
Volatile matter	35.13	.....
Fixed carbon	55.94	.....
Ash	5.58	3.95
Sulphur	.92	.88

COKING TESTS.

Test 63, Virginia No. 2.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 51 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,518
Breeze produced	do....	291
Coke produced	per cent..	62.65
Breeze produced	do....	2.43
Total percentage yield		65.08

Remarks.—Light gray and silvery. Good foundry coke. Large draft, giving more intense heat, would probably give better coke. Used small draft at first to hold charge as long as possible.

Test 69, Virginia No. 2.

Size as shipped, run of mine. Size as used, not crushed. Raw. Duration of test, 48 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,314
Breeze produced	do....	433
Coke produced	per cent..	60.95
Breeze produced	do....	3.61
Total percentage yield		64.56

Test 69, Virginia No. 2—Continued.

Remarks.—Light gray and silvery. Good heavy coke. Breeze content large, due to not grinding coal. Not as good as coke from ground charge. High yield due to deposited carbon.

Test 70, Virginia No. 2, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of est, 40 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,096
Breeze produced	do....	294
Coke produced	per cent..	60.96
Breeze produced	do....	2.94
Total percentage yield		63.90

Remarks.—Light gray and silvery. Good hard coke. Washing does not improve coke enough to warrant the expense. High yield due to deposited carbon.

ANALYSES.

	Test 63.		Test 69.		Test 70.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	3.88	0.25	3.86	0.69	5.96	0.45
Volatile matter	34.11	1.08	34.13	.93	34.17	1.23
Fixed carbon	57.01	91.25	56.39	90.33	56.03	92.25
Ash	5.00	7.42	5.62	8.05	3.84	6.07
Sulphur	1.02	.68	.79	.65	.91	.69

VIRGINIA NO. 3.

Bituminous coal from Coburn mine, Virginia Iron, Coal and Coke Company, Toms Creek, Wise County, Va., on the Norfolk and Western Railway.

This sample, which was loaded under the supervision of Inspector W. J. Von Borries, consisted of lump coal (over 3½-inch bar screen). It was used in making coking tests Nos. 61 and 88, steaming tests Nos. 280 and 283, and producer-gas test No. 75.

Two mine samples were taken for chemical analysis. No. 2281 is from the seventeenth east heading, 3,000 feet northeast of the drift mouth; No. 2282 is from room 3 off the eleventh west heading, 2,000 feet northeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2281	2282	2382
Air-drying loss		1.60	1.70	2.20
Proximate.	Moisture	2.70	2.91	3.05
	Volatile matter	32.45	31.99	31.65
	Fixed carbon	60.36	60.97	60.82
	Ash	4.49	4.13	4.48
	Sulphur	.52	.55	.67
Ultimate.	Hydrogen			5.17
	Carbon			80.35
	Nitrogen			1.59
	Oxygen			7.74
Calorific value determined:				
	Calories			8,039
	British thermal units			14,470

STEAMING TESTS.

Test 280, Virginia No. 3.

Size as shipped, over 3½ inches. Size as used, over 1 inch, 44.7 per cent; ½ inch to 1 inch, 20.2 per cent; ¼ inch to ½ inch, 15.7 per cent; under ¼ inch, 19.4 per cent. Duration of test, 9.88 hours. Kind of grate, rocking.

Test 283, Virginia No. 3.

Size as shipped, over 3½ inches. Size as used, over 1 inch, 32.8 per cent; ½ inch to 1 inch, 16.5 per cent; ¼ inch to ½ inch, 15.6 per cent; under ¼ inch, 35.1 per cent. Duration of test, 10 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 280.	Test 283.
Heating value of coal, B. T. U. per pound dry coal	14,908	14,936
Force of draft:		
Under stack damper, inch water	0.42	0.37
Above fire, do	.15	.16
Furnace temperature, °F.	2,452	2,537
Dry coal used per square foot of grate surface per hour, pounds	16.40	16.47
Equivalent water evaporated per square foot of water-heating surface per hour, pounds	2.91	2.99
Percentage of rated horsepower of boiler developed	81.6	83.8
Water apparently evaporated per pound of coal as fired, pounds	8.14	8.18
Water evaporated from and at 212° F.:		
Per pound of coal as fired, do	9.74	9.79
Per pound of dry coal, do	9.91	10.12
Per pound of combustible, do	10.66	10.84
Efficiency of boiler, including grate, per cent	64.19	65.43
Coal as fired:		
Per indicated horsepower hour, pounds	2.90	2.89
Per electrical horsepower hour, do	3.59	3.57
Dry coal:		
Per indicated horsepower hour, do	2.85	2.79
Per electrical horsepower hour, do	3.52	3.45

ANALYSES.

	Test 280.	Test 283.		Test 280.	Test 283.
Proximate.			*Ultimate.*		
Moisture	1.73	3.29	Carbon [a]	82.80	82.95
Volatile matter	33.25	32.00	Hydrogen [a]	4.98	4.98
Fixed carbon	60.35	60.20	Oxygen [a]	5.18	5.19
Ash	4.67	4.51	Nitrogen [a]	1.64	1.64
	100.00	100.00	Sulphur	.65	.58
Sulphur	.64	.56	Ash	4.75	4.66
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 75, Virginia No. 3.

Size as shipped, over 3½ inches. Size as used, over 1 inch, 51 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 13 per cent; under ¼ inch, 22 per cent. Duration of test, 50 hours.

Average electrical horsepower	194.8
Average B. T. U. gas, per cubic foot	156.4
Total coal fired, pounds	11,050

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 75.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.21	1.18	1.13
Developed at switch board	1.13	1.11	1.06
Per brake horsepower:			
Available for outside purposes	1.03	1.01	.96
Developed at engine	.96	.95	.90
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.29	1.27	1.21
Developed at switch board	1.21	1.19	1.13
Per brake horsepower:			
Available for outside purposes	1.10	1.08	1.03
Developed at engine	1.03	1.01	.96

ANALYSES.

	Test 75.		Test 75.
Coal.		*Gas by volume.*	
Moisture	1.66	Carbon dioxide (CO_2)	9.7
Volatile matter	31.68	Carbon monoxide (CO)	19.3
Fixed carbon	61.76	Hydrogen (H_2)	13.8
Ash	4.90	Methane (CH_4)	3.1
	100.00	Nitrogen (N_2)	54.1
Sulphur	.49		100.0

COKING TESTS.

Test 61, Virginia No. 3.

Size as shipped, over 3½ inches. Size as used, finely crushed. Raw. Duration of test, 45 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,160
Breeze produced	do....	240
Coke produced	per cent..	68.00
Breeze produced	do....	2.00
Total percentage yield		70.00

Remarks.—Light gray and silvery. Very heavy coke. Breaks in long, large, heavy pieces. Fine coke. High yield due to deposited carbon.

Test 88, Virginia No. 3.

Size as shipped, over 3½ inches. Size as used, same. Duration of test, 60 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,907
Breeze produced	do....	336
Coke produced	per cent..	65.89
Breeze produced	do....	2.80
Total percentage yield		68.69

Remarks.—Fine coke. Light gray and silvery. Very heavy. Breakage good; long, large pieces. Yield not so high and breeze higher than in coke from crushed coal.

ANALYSES.

	Test 61.		Test 88.	
	Coal.	Coke.	Coal.	Coke.
Moisture	2.87	0.29	2.49	0.16
Volatile matter	31.58	1.21	31.90	1.26
Fixed carbon	61.43	92.60	61.16	91.85
Ash	4.12	5.90	4.45	6.73
Sulphur	.56	.61	.57	.55

VIRGINIA NO. 4.

Bituminous coal from Darby mine, Darby Coal and Coke Company, Darby, Lee County, Va., on the Louisville and Nashville Railroad.

This sample was loaded under the supervision of Inspector J. W. Groves, and consisted of lump coal over 1½-inch bar screen. The following tests were made: Coking test No. 62, steaming tests Nos. 240, 248, 254, and 245, and producer-gas test No. 74.

Two mine samples were taken for chemical analysis. No. 2323 was cut in room 18 off the first butt entry, 1,423 feet from the drift mouth; No. 2324 was taken in room 1 off the third butt entry, 900 feet from the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2323	2324	2358
Air-drying loss		1.90	1.50	2.00
Proximate.	Moisture	3.89	3.55	4.35
	Volatile matter	34.89	37.06	36.89
	Fixed carbon	58.16	56.88	54.43
	Ash	3.06	2.51	4.33
Ultimate.	Sulphur	.34	.50	.79
	Hydrogen	.....	.....	5.25
	Carbon	.....	.....	76.99
	Nitrogen	.....	.....	1.32
	Oxygen	.....	.....	11.32
Calorific value determined:				
	Calories	7,858	.....	7,744
	British thermal units	14,144	.....	13,939

STEAMING TESTS.

Test 240, Virginia No. 4.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 46.5 per cent; ½ inch to 1 inch, 21.9 per cent; ¼ inch to 1 inch, 12.9 per cent; under ¼ inch, 18.7 per cent. Duration of test, 9.70 hours. Kind of grate, plain.

Test 248, Virginia No. 4.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 46.1 per cent; ½ inch to 1 inch, 20.4 per cent; ¼ inch to ½ inch, 12.5 per cent; under ¼ inch, 21.0 per cent. Duration of test, 8.02 hours. Kind of grate, plain. Limestone spread over grate at start.

Test 254, Virginia No. 4.

Size as shipped, over 1½ inches. Size as used, over 1 inch, 62.6 per cent; ½ inch to 1 inch, 15.4 per cent; ¼ inch to ½ inch, 7.9 per cent; under ¼ inch, 14.1 per cent. Duration of test, 10 hours. Kind of grate, plain. Limestone spread over grate at start.

Test 245, 2-3 Virginia No. 4 and 1-3 Pennsylvania No. 8 (dried).

Size as shipped, ovet 1½ inches and run of mine. Size as used, over 1 inch, 44.8 per cent; ½ inch to 1 inch, 13.6 per cent; ¼ inch to ½ inch, 9.3 per cent; under ¼ inch, 32.3 per cent. Coals mixed. Duration of test, 7.82 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 240.	Test 248.	Test 254.	Test 245.
Heating value of coal.....B. T. U. per pound dry coal..	14,558	14,677	14,414	14,476
Force of draft:				
Under stack damper.....inch water..	0.53	0.46	0.44	0.45
Above fire.....do....	.22	.11	.13	.12
Furnace temperature.....°F..	2,224	2,483	2,582	2,338
Dry coal used per square foot of grate surface per hour pounds.....	15.73	17.14	18.0	17.14
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.04	3.48	3.46	3.06
Percentage of rated horsepower of boiler developed.....	85.10	97.50	96.9	85.7
Water apparently evaporated per pound of coal as fired, pounds.....	7.83	8.23	7.76	7.27
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	9.33	9.81	9.22	8.66
Per pound of dry coal.....do....	9.66	10.18	9.62	8.93
Per pound of combustible.....do....	10.39	10.86	10.20	9.81
Efficiency of boiler, including grate.....per cent..	64.08	66.98	64.45	59.57
Coal as fired:				
Per indicated horsepower hour.....pounds..	3.03	2.88	3.07	3.27
Per electrical horsepower hour.....do....	3.74	3.56	3.79	4.03
Dry coal:				
Per indicated horsepower hour.....do....	2.93	2.78	2.94	3.17
Per electrical horsepower hour.....do....	3.61	3.43	3.63	3.91

ANALYSES.

	Test 240.	Test 248.	Test 254.	Test 245.
Proximate.				
Moisture.....	3.40	3.62	4.13	2.99
Volatile matter.....	36.01	35.84	36.18	28.16
Fixed carbon.....	55.87	56.58	56.09	63.30
Ash.....	4.72	3.96	3.60	5.55
	100.00	100.00	100.00	100.00
Sulphur.....	.49	.44	.44	.70

ANALYSES—continued.

	Test 240.	Test 248.	Test 254.	Test 245.
Ultimate.				
Carbon[a]	80.44	81.15	81.44	81.24
Hydrogen[a]	4.99	5.03	5.05	4.46
Oxygen[a]	7.79	7.86	7.89	6.45
Nitrogen[a]	1.38	1.39	1.40	1.41
Sulphur	.51	.46	.46	.72
Ash	4.89	4.11	3.76	5.72
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 74, Virginia No. 4.

Size as shipped, over 1¼ inches. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower	196.3
Average B. T. U. gas, per cubic foot	167.2
Total coal fired, pounds	12,200

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 74.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.31	1.28	1.24
Developed at switch board	1.24	1.21	1.18
Per brake horsepower:			
Available for outside purposes	1.12	1.09	1.05
Developed at engine	1.06	1.03	1.00
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.38	1.35	1.31
Developed at switch board	1.31	1.27	1.24
Per brake horsepower:			
Available for outside purposes	1.17	1.14	1.11
Developed at engine	1.11	1.08	1.05

ANALYSES.

	Test 74.		Test 74.
Coal.		*Gas by volume.*	
Moisture	2.72	Carbon dioxide (CO_2)	7.5
Volatile matter	36.79	Carbon monoxide (CO)	23.5
Fixed carbon	57.72	Hydrogen (H_2)	13.8
Ash	2.77	Methane (CH_4)	3.3
	100.00	Nitrogen (N_2)	51.9
Sulphur	.42		100.0

COKING TEST.

Test 62, Virginia No. 4.

Size as shipped, over 1½ inches. Size as used, finely crushed. Raw. Duration of test, 36 hours.

Coal charged	pounds..	10,000
Coke produced	do....	6,272
Breeze produced	do....	241
Coke produced	per cent..	62.72
Breeze produced	do....	2.41
Total percentage yield		65.13

Remarks.—Light gray and silvery. Fine-fingered coke. Breaks in long, thin pieces. Light-weight coke.

ANALYSES.

	Test 62.	
	Coal.	Coke.
Moisture	3.87	0.16
Volatile matter	36.39	1.14
Fixed carbon	55.60	92.90
Ash	4.14	5.80
Sulphur	.39	.42

WEST VIRGINIA NO. 4.

Bituminous coal from No. 2 mine, Elkins Coal Company, Bretz, Preston County, W. Va., on the Morgantown and Kingwood Railroad.

This sample, designated West Virginia No. 4 B in this report, consisted of run-of-mine coal. It was loaded under the supervision of Inspector J. W. Groves, and was used in making washing test No. 127 and coking tests Nos. 40, 44, and 46.[a]

Two mine samples were taken for chemical analysis, as follows: No. 2054 from the second left heading off the main entry, 1,300 feet from the drift mouth, and No. 2055 from the third right entry off the main entry, 800 feet southeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2054	2055	2250
Air-drying loss		2.40	2.30	2.60
Proximate.	Moisture	3.57	3.47	3.91
	Volatile matter	27.38	28.65	26.68
	Fixed carbon	62.84	62.70	59.30
	Ash	6.21	5.18	10.11
Ultimate.	Sulphur	.85	.80	1.07
	Hydrogen			4.69
	Carbon			74.73
	Nitrogen			1.56
	Oxygen			7.84
Calorific value determined:				
	Calories	7,899		7,428
	British thermal units	14,218		13,370

[a] For tests made during 1904 on the same coal see Bull. U. S. Geol. Survey No. 261, 1905, pp. 71, 82, 111, and 127.

WASHING TEST.

Test 127, West Virginia No. 4 B.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	26,600
Washed coal	do....	21,000
Refuse	do....	5,600

ANALYSES.

	Test 127.	
	Raw coal.	Washed coal.
Moisture	3.91	4.47
Volatile matter	26.68	.....
Fixed carbon	59.30	.....
Ash	10.11	7.76
Sulphur	1.07	.81

COKING TESTS.

Test 40, West Virginia No. 4 B.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 57 hours.

Coal charged	pounds..	10,000
Coke produced	do...	7,553
Breeze produced	do...	286
Coke produced	per cent..	75.53
Breeze produced	do...	2.86
Total percentage yield		78.39

Remarks.—Light gray and silvery. High yield due to deposited carbon. Breakage somewhat crosswise, but in good-sized pieces. Very good coke.

Test 44, West Virginia No. 4 B, washed.

Size as shipped, run of mine. Size as used, not crushed. Duration of test, 72 hours.

Coal charged	pounds..	12,000
Coke produced	do...	8,129
Breeze produced	do...	337
Coke produced	per cent..	67.74
Breeze produced	do...	2.81
Total percentage yield		70.55

Remarks.—Fine coke. Silvery color. Much deposited carbon. Heavy, good foundry coke. Breakage, practically perfect. Coal not ground. These tests would seem to indicate better coke physically from coal not ground, but per cent yield is lower, and the difference in yield would seem to warrant grinding.

Test 46, West Virginia No. 4 B, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 74 hours.

Coal charged	pounds..	9,760
Coke produced	do...	7,220
Breeze produced	do...	268
Coke produced	per cent..	73.98
Breeze produced	do...	2.75
Total percentage yield		76.73

Remarks.—Fine coke. Heavy, good-sized pieces, though breakage is not so good as coke from charge not ground. Unfortunate that charges were not same size, so as to make better comparison, but there were only 9,760 pounds of coal left. Yield better than coke from coal not ground. Washing does not improve enough to warrant this expense.

ANALYSES.

	Test 40.		Test 44.		Test 46.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	4.24	.35	5.40	.60	3.87	.27
Volatile matter	26.57	.68	26.83	1.20	27.72	1.37
Fixed carbon	58.89	86.01	59.90	87.04	59.67	86.98
Ash	10.30	12.96	7.87	11.16	8.74	11.38
Sulphur	.97	.82	.93	.72	.87	.78

WEST VIRGINIA NO. 13.

Bituminous coal from Page No. 2 mine, Loup Creek Colliery Company, Page, Fayette County, W. Va., on the Deep Water Railway and the Chesapeake and Ohio Railway.

This sample, which consisted of run-of-mine coal, was loaded under the supervision of E. W. Parker, of the United States Geological Survey. It was used in making coking test No. 21, steaming tests Nos. 179 and 180, and producer-gas test No. 56. It was also used, mixed with West Virginia No. 14, in making coking test No. 23.

Mine samples Nos. 1867 and 1868 were taken from the two distinct benches in the mine.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
	Laboratory number	[a] 1867	[b] 1868	2028
	Air-drying loss	4.50	1.90	2.60
Proximate.	Moisture	5.48	2.93	3.74
Proximate.	Volatile matter	29.70	31.95	31.04
Proximate.	Fixed carbon	62.53	60.17	61.31
Proximate.	Ash	2.29	4.95	3.91
Ultimate.	Sulphur	.79	1.22	.89
Ultimate.	Hydrogen	.....	.....	5.31
Ultimate.	Carbon	.....	.....	80.50
Ultimate.	Nitrogen	.....	.....	1.32
Ultimate.	Oxygen	.....	.....	8.07
	Calorific value determined:			
	Calories	8,030	.....	8,020
	British thermal units	14,454	.....	14,436

[a] Lower bench. [b] Upper bench.

STEAMING TESTS.

Test 179, West Virginia No. 13.

Size as shipped, run of mine. Size as used, over 1 inch, 15.4 per cent; ½ inch to 1 inch, 19.7 per cent; ¼ inch to ½ inch, 22.4 per cent; under ¼ inch, 42.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 180, West Virginia No. 13.

Size as shipped, run of mine. Size as used, over 1 inch, 12.7 per cent; ½ inch to 1 inch, 13.3 per cent; ¼ inch to ½ inch, 19.6 per cent; under ¼ inch, 54.4 per cent. Duration of test, 9.95 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 179.	Test 180.
Heating value of coal.....B. T. U. per pound dry coal..	14,999	14,933
Force of draft:		
Under stack damper.....inch water..	0.37	0.37
Above fire.....do....	.08	.10
Furnace temperature.....°F..	2,428	2,312
Dry coal used per square foot of grate surface per hour.....pounds..	16.47	15.19
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.45	3.22
Percentage of rated horsepower of boiler developed	96.8	90.1
Water apparently evaporated per pound of coal as fired .....pounds..	8.71	8.69
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	10.12	10.11
Per pound of dry coal.....do....	10.50	10.59
Per pound of combustible.....do....	11.11	11.29
Efficiency of boiler, including grate.....per cent..	67.60	68.48

MISCELLANEOUS ITEMS—continued.

	Test 179.	Test 180.
Coal as fired:		
Per indicated horsepower hour....pounds..	2.79	2.80
Per electrical horsepower hour....do....	3.45	3.45
Dry coal:		
Per indicated horsepower hour....do....	2.69	2.67
Per electrical horsepower hour....do....	3.32	3.30

ANALYSES.

	Test 179.	Test 180.		Test 179.	Test 180
Proximate.			*Ultimate.*		
Moisture	3.59	4.53	Carbon[a]	83.64	83.30
Volatile matter	30.88	29.82	Hydrogen[a]	5.09	5.07
Fixed carbon	61.69	61.38	Oxygen[a]	4.93	4.90
Ash	3.84	4.27	Nitrogen[a]	1.38	1.37
	100.00	100.00	Sulphur	.98	.89
Sulphur	.94	.85	Ash	3.98	4.47
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 56, West Virginia No. 13.

Size as shipped, run of mine. Size as used, over 1 inch, 25 per cent; ½ inch to 1 inch, 42 per cent; ¼ inch to ½ inch, 20 per cent; under ¼ inch, 13 per cent. Duration of test, 50 hours.

Average electrical horsepower.... 200.5
Average B. T. U. gas, per cubic foot.... 139.2
Total coal fired....pounds.. 9,750

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 56.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.03	1.00	0.96
Developed at switch board	.97	.95	.91
Per brake horsepower:			
Available for outside purposes	.87	.85	.82
Developed at engine	.83	.80	.78
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.10	1.07	1.03
Developed at switch board	1.04	1.01	.97
Per brake horsepower:			
Available for outside purposes	.93	.91	.87
Developed at engine	.88	.86	.83

ANALYSES.

	Test 56.		Test 56.
Coal.		*Gas by volume.*	
Moisture	2.65	Carbon dioxide (CO_2)	9.8
Volatile matter	31.00	Carbon monoxide (CO)	18.4
Fixed carbon	62.82	Hydrogen (H_2)	13.7
Ash	3.53	Methane (CH_4)	2.3
	100.00	Nitrogen (N_2)	55.8
Sulphur	.82		100.0

COKING TESTS.

Test 21, West Virginia No. 13.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 84 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,955
Breeze produced	do....	413
Coke produced	per cent..	66.29
Breeze produced	do....	3.44
Total percentage yield		69.73

Remarks.—Good, hard coke. Foundry coke. Light-gray and silvery color. High yield due to deposited carbon.

Test 23, West Virginia No. 13 and 14 mixed in equal proportions.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 77 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,093
Breeze produced	do....	215
Coke produced	per cent..	67.44
Breeze produced	do....	1.79
Total percentage yield		69.23

Remarks.—Good, hard coke. Foundry coke. Light-gray and silvery color. High yield due to deposited carbon.

ANALYSES.

	Test 21.		Test 23.	
	Coal.	Coke.	Coal.	Coke.
Moisture	3.23	0.75	4.81	0.43
Volatile matter	31.12	1.05	29.28	1.37
Fixed carbon	61.98	93.36	62.84	94.20
Ash	3.67	4.84	3.07	4.00
Sulphur	.86	.77	.89	.84

WEST VIRGINIA NO. 14.

Bituminous coal from Page No. 1 mine, Loup Creek Colliery Company, Page, Fayette County, W. Va., on the Deep Water Railway and the Chesapeake and Ohio Railway.

This sample consisted of run-of-mine coal and was shipped under the supervision of E. W. Parker, of the United States Geological Survey. The following tests were made: Coking test No. 20, steaming tests Nos. 178 and 181, and producer-gas test No. 54. It was also used mixed with West Virginia No. 13 in making coking test No. 23.

Three mine samples were taken in this mine. No. 1869 was cut from the lower bench, No. 1870 from the middle bench, and No. 2178 was a sample of the entire seam.

CHEMICAL ANALYSES.

		Mine samples.			Car sample.
Laboratory number		[a] 1869	[b] 1870	2178	2004
Air-drying loss		2.30	1.80	3.20	3.10
Proximate.	Moisture	3.53	2.96	4.11	5.09
	Volatile matter	29.36	30.23	29.08	29.07
	Fixed carbon	64.77	59.37	59.36	62.57
	Ash	2.34	7.44	7.45	3.27
Ultimate.	Sulphur	.92	1.04	.80	1.03
	Hydrogen	.....	.....	.....	5.33
	Carbon	.....	.....	.....	78.23
	Nitrogen	.....	.....	.....	1.51
	Oxygen	.....	.....	.....	10.63
Calorific value determined:					
	Calories	.....	7,762	.....	7,839
	British thermal units	.....	13,972	.....	14,110

[a] Lower bench. [b] Middle bench.

STEAMING TESTS.

Test 178, West Virginia No. 14.

Size as shipped, run of mine. Size as used, over 1 inch, 26.8 per cent; ½ inch to 1 inch, 14.5 per cent; ¼ inch to ½ inch, 16.7 per cent; under ¼ inch, 42 per cent. Duration of test, 10 hours. Kind of grate, plain.

Test 181, West Virginia No. 14.

Size as shipped, run of mine. Size as used, over 1 inch, 23.1 per cent; ½ inch to 1 inch, 15.5 per cent; ¼ inch to ½ inch, 16.4 per cent; under ¼ inch, 45 per cent. Duration of test, 7.60 hours. Kind of grate, plain. Limestone spread over grate at start.

MISCELLANEOUS ITEMS.

		Test 178.	Test 181.
Heating value of coal	B. T. U. per pound dry coal	15,048	15,003
Force of draft:			
Under stack damper	inch water	0.42	0.50
Above fire	do	.16	.13
Furnace temperature	°F	2,337	2,459
Dry coal used per square foot of grate surface per hour	pounds	14.38	19.31
Equivalent water evaporated per square foot of water-heating surface per hour, pounds		3.02	3.70
Percentage of rated horsepower of boiler developed		84.6	103.8
Water apparently evaporated per pound of coal as fired	pounds	8.80	7.84
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	10.22	9.11
Per pound of dry coal	do	10.52	9.60
Per pound of combustible	do	10.88	10.14
Efficiency of boiler, including grate	per cent	67.51	61.79
Coal as fired:			
Per indicated horsepower hour	pounds	2.77	3.10
Per electrical horsepower hour	do	3.41	3.83
Dry coal:			
Per indicated horsepower hour	do	2.69	2.95
Per electrical horsepower hour	do	3.32	3.64

ANALYSES.

	Test 178.	Test 181.		Test 178.	Test 181.
Proximate.			*Ultimate.*		
Moisture	2.85	5.15	Carbon [a]	83.41	83.16
Volatile matter	30.13	28.38	Hydrogen [a]	5.07	5.06
Fixed carbon	64.78	64.09	Oxygen [a]	6.51	6.50
Ash	2.24	2.38	Nitrogen [a]	1.61	1.60
	100.00	100.00	Sulphur	1.09	1.17
Sulphur	1.06	1.11	Ash	2.31	2.51
				100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 54, West Virginia No. 14.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 47 hours.

Average electrical horsepower 201.3
Average B. T. U. gas, per cubic foot 147.0
Total coal fired, pounds 9,750

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 54.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.08	1.05	1.02
Developed at switch board	1.03	1.00	.97
Per brake horsepower:			
Available for outside purposes	.92	.89	.87
Developed at engine	.87	.85	.82
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.15	1.12	1.08
Developed at switch board	1.10	1.06	1.03
Per brake horsepower:			
Available for outside purposes	.98	.95	.92
Developed at engine	.93	.90	.88

ANALYSES.

	Test 54.		Test 54.
Coal.		*Gas by volume.*	
Moisture	3.12	Carbon dioxide (CO_2)	8.6
Volatile matter	28.99	Carbon monoxide (CO)	20.7
Fixed carbon	65.22	Hydrogen (H_2)	13.3
Ash	2.67	Methane (CH_4)	2.3
	100.00	Nitrogen (N_2)	55.1
Sulphur	1.21		100.0

COKING TEST.

Test 20, West Virginia No. 14.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 71 hours.

Coal charged	pounds..	11,000
Coke produced	do....	7,154
Breeze produced	do....	364
Coke produced	per cent..	65.04
Breeze produced	do....	3.31
Total percentage yield		68.35

Remarks.—Good hard coke. Foundry coke. Light-gray and silvery color. High yield due to deposited carbon.

ANALYSES.

	Test 20.	
	Coal.	Coke.
Moisture	1.04	0.38
Volatile matter	29.28	.96
Fixed carbon	66.80	95.19
Ash	2.88	3.47
Sulphur	1.04	.94

WEST VIRGINIA NO. 15.

Bituminous coal from Ocean mine, Fairmont Coal Company, 3 miles east of Clarksburg, Harrison County, W. Va., on the Baltimore and Ohio Railroad.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. S. Burrows. It was used in making coking tests Nos. 36 and 43 and steaming tests Nos. 214, 215, and 216.

Two mine samples were taken for chemical analysis. No. 2039 was cut from the second butt entry off the third face entry, 2,750 feet northwest of the drift mouth. No. 2040 was cut in room 7 off the third butt entry, 2,025 feet northeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2039	2040	2195
Air-drying loss		1.50	1.90	0.90
Proximate.	Moisture	2.80	3.27	2.01
	Volatile matter	38.51	37.72	37.31
	Fixed carbon	53.14	53.27	52.13
	Ash	5.55	5.74	8.55
Ultimate.	Sulphur	2.40	2.41	2.54
	Hydrogen			5.08
	Carbon			75.83
	Nitrogen			1.43
	Oxygen			6.57
Calorific value determined:				
	Calories	7,836		7,673
	British thermal units	14,105		13,811

STEAMING TESTS.

Test 214, West Virginia No. 15.

Size as shipped, run of mine. Size as used, over 1 inch, 33.1 per cent; ½ inch to 1 inch, 24.4 per cent; ¼ inch to ½ inch, 15 per cent; under ¼ inch, 27.5 per cent. Duration of test, 8.78 hours. Kind of grate, rocking.

Test 215, West Virginia No. 15.

Size as shipped, run of mine. Size as used, over 1 inch, 32.6 per cent; ½ inch to 1 inch, 24.2 per cent; ¼ inch to ½ inch, 15.8 per cent; under ¼ inch, 27.4 per cent. Duration of test, 9.75 hours. Kind of grate, plain.

Test 216, West Virginia No. 15.

Size as shipped run of mine. Size as used, over 1 inch, 43.5 per cent; ½ inch to 1 inch, 20.3 per cent; ¼ inch to ½ inch, 14.5 per cent; under ¼ inch, 21.7 per cent. Duration of test, 5.80 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 214.	Test 215.	Test 216.
Heating value of coal.....B. T. U. per pound dry coal..	14,126	14,202	14,197
Force of draft:			
Under stack damper.....inch water..	0.53	0.40	0.41
Above fire.....do....	.22	.12	[a].04
Furnace temperature.....°F..	2,247	2,269	2,365
Dry coal used per square foot of grate surface per hour.....pounds..	16.32	16.77	21.28
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.68	3.01	3.67
Percentage of rated horsepower of boiler developed.....	75.2	84.4	103.0
Water apparently evaporated per pound of coal as fired.....pounds..	7.65	7.44	7.14
Water evaporated from and at 212 °F.:			
Per pound of coal as fired.....do....	9.00	8.77	8.41
Per pound of dry coal.....do....	9.18	8.99	8.65
Per pound of combustible.....do....	10.92	10.04	9.63
Efficiency of boiler, including grate.....per cent..	62.76	61.13	58.84
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.14	3.22	3.36
Per electrical horsepower hour.....do....	3.88	3.98	4.15
Dry coal:			
Per indicated horsepower hour.....do....	3.08	3.15	3.27
Per electrical horsepower hour.....do....	3.80	3.88	4.04

[a] Forced draft.

ANALYSES.

	Test 214.	Test 215.	Test 216.		Test 214.	Test 215.	Test 216.
Proximate.				*Ultimate.*			
Moisture.....	1.90	2.47	2.73	Carbon [a].....	77.45	77.93	77.90
Volatile matter....	38.18	38.38	38.43	Hydrogen [a].....	4.97	5.00	5.00
Fixed carbon.....	51.90	51.48	51.11	Oxygen [a].....	4.87	4.90	4.89
Ash.....	8.02	7.67	7.73	Nitrogen [a].....	1.46	1.47	1.47
	100.00	100.00	100.00	Sulphur.....	3.07	2.84	2.79
Sulphur.....	3.01	2.77	2.71	Ash.....	8.18	7.86	7.95
					100.00	100.00	100.00

[a] Figured from car sample.

COKING TESTS.

Test 36, West Virginia No. 15.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 46 hours.

Coal charged	pounds	10,000
Coke produced	do	6,867
Breeze produced	do	267
Coke produced	per cent	68.67
Breeze produced	do	2.76
Total percentage yield		71.43

Remarks.—Light gray and silvery. Good, heavy coke. High yield due to deposited carbon. Sulphur high.

Test 43, West Virginia No. 15.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 73 hours.

Coal charged	pounds	12,000
Coke produced	do	8,404
Breeze produced	do	269
Coke produced	per cent	70.03
Breeze produced	do	2.24
Total percentage yield		72.27

Remarks.—Fine heavy coke. Silvery color. Breakage practically perfect; large pieces. Sulphur high. High yield due to deposited carbon.

ANALYSES.

	Test 36.		Test 43.	
	Coal.	Coke.	Coal.	Coke.
Moisture	1.79	0.45	2.33	0.26
Volatile matter	37.90	.78	38.33	1.89
Fixed carbon	53.00	88.70	51.72	87.30
Ash	7.31	10.07	7.62	10.55
Sulphur	2.73	2.09	2.72	2.26

WEST VIRGINIA NO. 16.

Bituminous coal from Monongha mine No. 6, Fairmont Coal Company, Monongha, Marion County, W. Va., on the Baltimore and Ohio Railroad.

Two samples of coal were shipped from this mine under the supervision of Inspector J. S. Burrows. West Virginia No. 16 A consisted of three-fourths inch lump coal over a three-fourths inch screen. It was used in making coking test No. 73 and producer-gas test No. 86. West Virginia No. 16 B consisted of slack coal which had passed through a three-fourths inch screen. It was used in making washing test No. 128 and coking tests Nos. 45, 48, and 49.

Two mine samples were taken from this mine for chemical analysis as follows: No. 2041 from room 2 on the third right entry, 5,000 feet southwest of the drift mouth; No. 2042 from room 1 off the third left entry, 5,000 feet northwest of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2041	2042	2264
Air-drying loss		1.30	1.40	4.40
Proximate.	Moisture	2.89	2.68	5.57
	Volatile matter	34.54	35.97	31.61
	Fixed carbon	56.86	55.78	54.45
	Ash	5.71	5.57	8.37
Ultimate.	Sulphur	.69	1.06	1.20
	Hydrogen			5.08
	Carbon			72.74
	Nitrogen			1.46
	Oxygen			11.15
Calorific value determined:				
	Calories	7,800		7,274
	British thermal units	14,540		13,093

PRODUCER-GAS TEST.

Test 86, West Virginia No. 16 A.

Size as shipped, over ¾ inch. Size as used, over 1 inch, 86 per cent; ½ inch to 1 inch, 5 per cent; ¼ inch to ½ inch, 4 per cent; under ¼ inch, 5 per cent. Duration of test, 50 hours.

Average electrical horsepower	198.5
Average B. T. U. gas, per cubic foot	156.1
Total coal fired ..... pounds..	13,150

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 86.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.41	1.38	1.28
Developed at switch board	1.33	1.30	1.20
Per brake horsepower:			
Available for outside purposes	1.20	1.17	1.09
Developed at engine	1.13	1.10	1.02
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.49	1.45	1.35
Developed at switch board	1.40	1.37	1.27
Per brake horsepower:			
Available for outside purposes	1.26	1.24	1.15
Developed at engine	1.19	1.16	1.08

ANALYSES.

	Test 86.		Test 86.
Coal.		*Gas by volume.*	
Moisture	2.28	Carbon dioxide (CO_2)	8.4
Volatile matter	35.54	Carbon monoxide (CO)	21.2
Fixed carbon	55.29	Hydrogen (H_2)	14.0
Ash	6.89	Methane (CH_4)	2.5
	100.00	Nitrogen (N_2)	53.9
Sulphur	0.95		100.0

WASHING TEST.

Test 128, West Virginia No. 16 B.

Size as shipped, slack. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	22,825
Washed coal	do....	19,800
Refuse	do....	3,025

ANALYSES.

	Test 128.	
	Raw coal.	Washed coal.
Moisture	5.57	5.41
Volatile matter	31.61	.....
Fixed carbon	54.45	.....
Ash	8.37	5.91
Sulphur	1.20	.82

COKING TESTS.

Test 73, West Virginia No. 16 A.

Size as shipped, over ¾ inch. Size as used, finely crushed. Raw. Duration of test, 60 hours.

Coal charged	pounds..	14,000
Coke produced	do....	9,700
Breeze produced	do....	384
Coke produced	per cent..	69.29
Breeze produced	do....	2.74
Total percentage yield		72.03

Remarks.—Light gray and silvery; much deposited carbon to which high yield is due. Fine hard, heavy coke.

Test 45, West Virginia No. 16 B.

Size as shipped, slack. Size as used, finely crushed. Raw. Duration of test, 72 hours.

Coal charged	pounds..	21,000
Coke produced	do....	8,124
Breeze produced	do....	276
Coke produced	per cent..	67.70
Breeze produced	do....	2.30
Total percentage yield		70.00

Remarks.—Fine heavy coke. Silvery color. Breakage practically perfect; large pieces. Good foundry coke if sulphur was reduced a little. High yield due to deposited carbon.

Test 48, West Virginia No. 16 B, washed.

Size as shipped, slack. Size as used, finely crushed. Duration of test, 47 hours.

Test 48, West Virginia No. 16 B.—Continued.

Coal charged	pounds..	12,000
Coke produced	do....	7,984
Breeze produced	do....	289
Coke produced	per cent..	66.53
Breeze produced	do....	2.41
Total percentage yield		68.94

Remarks.—Light gray and silvery. Light coke. Brittle. Ash and sulphur reduced by washing, but physical properties not so good as coke from raw charge. High yield due to deposited carbon.

Test 49, West Virginia No. 16 B, washed.

Size as shipped, slack. Size as used, finely crushed. Duration of tests, 25 hours.

Coal charged	pounds..	7,800
Coke produced	do....	5,207
Breeze produced	do....	175
Coke produced	per cent..	66.76
Breeze produced	do....	2.24
Total percentage yield		69.00

Remarks.—Light gray and silvery. Light coke. Brittle. Ash and sulphur reduced by washing, but physical properties not so good as coke from raw charge. High yield due to deposited carbon.

ANALYSES.

	Test 73.		Test 45.		Test 48.		Test 49.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	2.93	0.54	5.70	0.40	5.31	0.37	4.59	0.38
Volatile matter	35.20	1.31	32.52	1.55	32.83	1.18	33.90	2.35
Fixed carbon	55.26	89.07	53.44	85.61	55.89	89.87	55.71	88.91
Ash	6.61	9.08	8.34	12.44	5.97	8.58	5.80	8.36
Sulphur	0.92	0.81	1.20	1.23	0.97	0.91	0.95	0.89

WEST VIRGINIA NO. 17.

Bituminous coal from a country bank 2½ miles above Bretz, Preston County, W. Va., on the Morgantown and Kingwood Railroad. This coal was furnished by the Elkins Coal Company, of Bretz, W. Va.

This sample, which consisted of run-of-mine coal, was loaded under the supervision of Inspector J. W. Groves and hauled to the Morgantown and Kingwood Railroad. It was used in making washing test No. 132, coking test No. 60, steaming tests Nos. 225 and 226, and steaming test on washed coal No. 230.

Two mine samples (Nos. 2056 and 2057) were taken from a prospect hole about one-fourth mile below the country bank from which the coal was shipped.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2056	2057	2332
Air-drying loss		2.30	3.10	2.50
Proximate.	Moisture	3.22	4.05	3.46
	Volatile matter	29.54	28.70	27.20
	Fixed carbon	59.91	61.65	61.13
	Ash	7.33	5.60	8.12
Ultimate.	Sulphur	1.73	1.16	1.45
	Hydrogen	.....	.....	4.68
	Carbon	.....	.....	76.98
	Nitrogen	.....	.....	1.37
	Oxygen	.....	.....	7.40
Calorific value determined:				
	Calories	7,775	.....	7,705
	British thermal units	13,995	.....	13,869

STEAMING TESTS.

Test 225, West Virginia No. 17.

Size as shipped, run of mine. Size as used, over 1 inch, 11 per cent; ½ inch to 1 inch, 11 per cent; ¼ inch to ½ inch, 16.2 per cent; under ¼ inch, 61.8 per cent. Duration of test, 9.92 hours. Kind of grate, rocking.

Test 226, West Virginia No. 17.

Size as shipped, run of mine. Size as used, over 1 inch, 16.5 per cent; ½ inch to 1 inch, 14 per cent; ¼ inch to ½ inch, 15.3 per cent; under ¼ inch, 54.2 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

Test 230, West Virginia No. 17, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 29.6 per cent; ½ inch to 1 inch, 20.2 per cent; ¼ inch to ½ inch, 15.7 per cent; under ¼ inch, 34.5 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 225.	Test 226.	Test 230.
Heating value of coal.....B. T. U. per pound dry coal..	14,546	14,508	14,641
Force of draft:			
Under stack damper.....inch water..	0.53	0.61	0.48
Above fire.....do....	.16	.17	.19
Furnace temperature.....°F..	2,165	.....	2,392
Dry coal used per square foot of grate surface per hour.....pounds..	16.37	17.56	17.64
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.00	3.13	3.17
Percentage of rated horsepower of boiler developed.....	84.1	87.6	89.0
Water apparently evaporated per pound of coal as fired.....pounds.	8.30	8.06	8.03
Water evaporated from and at 212 °F.:			
Per pound of coal as fired.....do....	9.79	9.53	9.61
Per pound of dry coal.....do....	10.22	9.94	10.05
Per pound of combustible.....do....	11.32	11.04	11.01
Efficiency of boiler, including grate.....per cent..	67.85	66.16	66.29
Coal as fired:			
Per indicated horsepower hour.....pounds..	2.89	2.97	2.94
Per electrical horsepower hour.....do....	3.57	3.66	3.63
Dry coal:			
Per indicated horsepower hour.....do....	2.77	2.84	2.81
Per electrical horsepower hour.....do....	3.42	3.51	3.47

ANALYSES.

	Test 225.	Test 226.	Test 230.		Test 225.	Test 226.	Test 230.
Proximate.				*Ultimate.*			
Moisture	4.14	4.10	4.35	Carbon[a]	80.79	80.59	81.56
Volatile matter	27.89	27.92	28.35	Hydrogen[a]	4.51	4.49	4.55
Fixed carbon	60.87	60.58	61.13	Oxygen[a]	4.51	4.50	4.57
Ash	7.10	7.40	6.17	Nitrogen[a]	1.44	1.44	1.45
	100.00	100.00	100.00	Sulphur	1.34	1.26	1.42
Sulphur	1.28	1.21	1.36	Ash	7.41	7.72	6.45
					100.00	100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 132, West Virginia No. 17.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	29,530
Washed coal	do	24,765
Refuse	do	4,765

ANALYSES.

	Test 132.	
	Raw coal.	Washed coal.
Moisture	3.46	5.33
Volatile matter	27.29	.....
Fixed carbon	61.13	.....
Ash	8.12	5.50
Sulphur	1.45	1.14

COKING TEST.

Test 60, West Virginia No. 17, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 42 hours.

Coal charged	pounds	10,000
Coke produced	do	6,675
Breeze produced	do	293
Coke produced	per cent	66.75
Breeze produced	do	2.93
Total percentage yield		69.68

Remarks.—Light gray and silvery. Good weight coke. Brittle and breaks badly. High yield due to deposited carbon. This was outcrop coal, and results are exceedingly good under these circumstances.

ANALYSES.

	Test 60.	
	Coal.	Coke.
Moisture	4.84	0.07
Volatile matter	28.63	.63
Fixed carbon	60.49	91.36
Ash	6.04	7.94
Sulphur	1.25	1.04

WEST VIRGINIA NO. 18.

Bituminous coal from Glen Alum mine, Glen Alum Fuel Company, Glen Alum, Mingo County, W. Va., on the Norfolk and Western Railway.

This sample consisted of run-of-mine coal, and was loaded under the supervision of Inspector J. W. Groves. It was used in making coking tests Nos. 74 and 78, steaming tests Nos. 259, 261, and 262, and producer-gas test No. 80.

Two mine samples were taken from this mine for chemical analysis, as follows: No. 2348 from a crosscut 900 feet from the drift mouth, and No. 2349 from room 19, off the twentieth entry, 3,000 feet from the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2348	2349	2527
Air-drying loss		1.50	2.40	1.60
Proximate.	Moisture	2.81	4.04	2.86
	Volatile matter	31.07	31.25	33.23
	Fixed carbon	59.02	59.55	58.08
	Ash	6.50	5.16	5.83
Ultimate.	Sulphur	0.66	.64	.67
	Hydrogen	.....	.....	5.01
	Carbon	.....	.....	78.38
	Nitrogen	.....	.....	1.43
	Oxygen	.....	.....	8.68
Calorific value determined:				
	Calories	7,754	.....	7,836
	British thermal units	13,957	.....	14,106

STEAMING TESTS.

Test 259, West Virginia No. 18.

Size as shipped, run of mine. Size as used, over 1 inch, 44.8 per cent; ½ inch to 1 inch, 18.1 per cent; ¼ inch to ½ inch, 12 per cent; under ¼ inch 25.1 per cent. Test run on an ordinary Frost fire-tube boiler. Duration of test, 9.95 hours. Kind of grate, rocking.

Test 261, West Virginia No. 18.

Size as shipped, run of mine. Size as used, over 1 inch, 22.4 per cent; ½ inch to 1 inch, 20 per cent; ¼ inch to ½ inch, 17.1 per cent; under ¼ inch, 40.5 per cent. Duration of test, 10 hours. Kind of grate, rocking.

Test 262, West Virginia No. 18.

Size as shipped, run of mine. Size as used, over 1 inch, 47.7 per cent; ½ inch to 1 inch, 17.2 per cent; ¼ inch to ½ inch, 11.9 per cent; under ¼ inch, 23.2 per cent. Duration of test, 10.07 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 259.	Test 261.	Test 262.
Heating value of coal.....B. T. U. per pound dry coal..	14,476	14,414	14,384
Force of draft:			
Under stack damper.....inch water..	0.18	0.39	0.50
Above fire.....do....	.15	.13	.18
Furnace temperature.....°F..	(a)	2,590	2,600
Dry coal used per square foot of grate surface per hour .....pounds..	.....	17.80	20.44
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	.....	3.35	3.77
Percentage of rated horsepower of boiler developed.....	b100.0	93.8	105.6
Water apparently evaporated per pound of coal as fired.....pounds..	7.38	8.46	8.31
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	8.73	10.17	10.0
Per pound of dry coal.....do....	9.00	10.49	10.29
Per pound of combustible.....do....	9.71	11.41	11.19
Efficiency of boiler, including grate.....per cent..	60.04	70.28	69.08
Coal as fired:			
Per indicated horsepower hour.....pounds..	3.24	2.78	2.83
Per electrical horsepower hour.....do....	4.00	3.43	3.49
Dry coal:			
Per indicated horsepower hour.....do....	3.14	2.69	2.75
Per electrical horsepower hour.....do....	3.88	3.33	3.39

a Too low to read with pyrometer. b Approximated.

ANALYSES.

	Test 259.	Test 261.	Test 262.		Test 259.	Test 261.	Test 262.
Proximate.				*Ultimate.*			
Moisture.....	3.07	3.02	2.74	Carbon[a].....	80.45	80.08	79.91
Volatile matter....	32.71	32.79	32.52	Hydrogen[a].....	4.82	4.79	4.78
Fixed carbon.....	58.12	57.66	58.02	Oxygen[a].....	6.30	6.26	6.24
Ash.....	6.10	6.53	6.72	Nitrogen[a].....	1.46	1.46	1.45
	100.00	100.00	100.00	Sulphur.....	0.68	0.68	0.71
Sulphur.....	0.66	0.66	0.69	Ash.....	6.29	6.73	6.91
					100.00	100.00	100.00

a Figured from car sample.

PRODUCER-GAS TEST.

Test 80, West Virginia No. 18.

Size as shipped, run of mine. Size as used, over 1 inch, 69 per cent; ½ inch to 1 inch, 13 per cent; ¼ inch to ½ inch, 7 per cent, under ¼ inch, 11 per cent. Duration of test, 50 hours.

Average electrical horsepower.....	197.9
Average B. T. U. gas, per cubic foot	158.9
Total coal fired.....pounds..	11,250

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 80.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.20	1.17	1.10
Developed at switch board	1.14	1.11	1.04
Per brake horsepower:			
Available for outside purposes	1.02	1.00	0.94
Developed at engine	0.97	0.94	.88
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.27	1.24	1.17
Developed at switch board	1.20	1.17	1.10
Per brake horsepower:			
Available for outside purposes	1.08	1.05	0.99
Developed at engine	1.02	0.99	.94

ANALYSES.

	Test 80.		Test 80.
Coal.		*Gas by volume.*	
Moisture	2.66	Carbon dioxide (CO_2)	8.6
Volatile matter	32.71	Carbon monoxide (CO)	21.5
Fixed carbon	58.89	Hydrogen (H_2)	12.9
Ash	5.74	Methane (CH_4)	3.7
	100.00	Nitrogen (N_2)	53.3
Sulphur	0.65		100.0

COKING TESTS.

Test 74, West Virginia No. 18.

Size as shipped run of mine. Size as used, not crushed Raw. Duration of test, 43 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,444
Breeze produced	do....	309
Coke produced	per cent..	70.37
Breeze produced	do....	2.58
Total percentage yield		72.95

Remarks.—Light gray and silvery. Good, hard, heavy coke. High yield due to deposited carbon.

Test 78, West Virginia No. 18.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 48 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,422
Breeze produced	do....	340
Coke produced	per cent..	70.18
Breeze produced	do....	2.83
Total percentage yield		73.01

Remarks.—Light gray and silvery. Good, hard, heavy coke. High yield due to deposited carbon.

ANALYSES.

	Test 74.		Test 78.	
	Coal.	Coke.	Coal.	Coke.
Moisture	3.42	0.63	4.18	0.69
Volatile matter	32.82	.97	32.08	1.19
Fixed carbon	57.02	89.54	57.69	89.47
Ash	6.74	8.86	6.05	8.65
Sulphur	0.70	0.54	0.61	0.53

WEST VIRGINIA NO. 19.

Bituminous coal from McDonald mine, White Oak Coal Company, McDonald, Fayette County, W. Va., on the Chesapeake and Ohio Railway.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. W. Groves. It was used in making coking tests Nos. 79 and 83 and steaming tests Nos. 285 and 289.

Two mine samples were taken from this mine for chemical analysis, as follows: No. 2359 from room 11 off the eighteenth left entry, 7,720 feet from the drift mouth; No. 2360 from room 16 on the sixteenth right entry, 7,600 feet southwest of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2359	2360	2549
Air-drying loss		2.50	2.80	2.30
Proximate.	Moisture	3.26	3.51	2.96
	Volatile matter	21.57	21.11	22.74
	Fixed carbon	72.71	72.83	69.29
	Ash	2.46	2.55	5.01
Ultimate.	Sulphur	.78	.53	.89
	Hydrogen	.....	.....	4.81
	Carbon	.....	.....	81.64
	Nitrogen	.....	.....	1.57
	Oxygen	.....	.....	6.08
Calorific value determined:				
Calories		8,207	.....	8,014
British thermal units		14,773	.....	14,425

STEAMING TESTS.

Test 285, West Virginia No. 19.

Size as shipped, run of mine. Size as used, over 1 inch, 14.8 per cent; ½ inch to 1 inch, 11.6 per cent; ¼ inch to ½ inch, 15.3 per cent; under ¼ inch, 58.3 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

Test 289, West Virginia No. 19.

Size as shipped, run of mine. Size as used, over 1 inch, 13.4 per cent; ½ inch to 1 inch, 11.7 per cent; ¼ inch to ½ inch, 16.2 per cent; under ¼ inch, 58.7 per cent. Duration of test, 8 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

		Test 285.	Test 289.
Heating value of coal	B. T. U. per pound dry coal	14,618	14,571
Force of draft:			
Under stack damper	inch water	0.45	0.56
Above fire	do	.22	.12
Furnace temperature	°F.	2,419	2,065
Dry coal used per square foot of grate surface per hour	pounds	15.55	13.86
Equivalent water evaporated per square foot of water-heating surface per hour, pounds		2.92	2.84
Percentage of rated horsepower of boiler developed		81.8	79.6
Water apparently evaporated per pound of coal as fired	pounds	8.53	8.25
Water evaporated from and at 212° F.:			
Per pound of coal as fired	do	10.20	9.94
Per pound of dry coal	do	10.45	10.26
Per pound of combustible	do	11.48	11.45
Efficiency of boiler, including grate	per cent	69.04	68.00

MISCELLANEOUS ITEMS—continued.

	Test 285.	Test 289.
Coal as fired:		
Per indicated horsepower hour.....pounds..	2.77	2.84
Per electrical horsepower hour.....do....	3.42	3.51
Dry coal:		
Per indicated horsepower hour.....do....	2.71	2.76
Per electrical horsepower hour.....do....	3.34	3.40

ANALYSES.

	Test 285.	Test 289.		Test 285.	Test 289.
Proximate.			*Ultimate.*		
Moisture	2.44	3.07	Carbon [a]	82.72	82.43
Volatile matter	20.59	20.58	Hydrogen [a]	4.54	4.52
Fixed carbon	70.43	69.66	Oxygen [a]	3.51	3.49
Ash	6.54	6.69	Nitrogen [a]	1.59	1.59
	100.00	100.00	Sulphur	.94	1.07
Sulphur	0.92	1.04	Ash	6.70	6.90
				100.00	100.00

[a] Figured from car sample.

COKING TESTS.

Test 79, West Virginia No. 19.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 49 hours.

Coal charged.....pounds..	12,000
Coke produced.....do....	7,692
Breeze produced.....do....	258
Coke produced.....per cent..	64.10
Breeze produced.....do....	2.15
Total percentage yield.....	66.25

Remarks.—Dull-gray color; slightly silvery. Light weight. Poor, dense coke.

Test 83, West Virginia No. 19.

Size as shipped, run of mine. Size as used finely crushed. Raw. Duration of test, 53 hours.

Coal charged.....pounds..	12,000
Coke produced.....do....	7,914
Breeze produced.....do....	283
Coke produced.....per cent..	65.95
Breeze produced.....do....	2.36
Total percentage yield.....	68.31

Remarks.—Dull-gray color, with slight silvery luster; cell structure small. Much heavier and better than in test 79.

ANALYSES.

	Test 79.		Test 83.	
	Coal.	Coke.	Coal.	Coke.
Moisture	2.82	0.38	2.43	0.45
Volatile matter	20.63	1.68	21.34	.55
Fixed carbon	70.30	89.96	70.50	91.57
Ash	6.25	7.98	5.73	7.43
Sulphur	1.00	.77	.96	.82

WEST VIRGINIA NO. 20.

Bituminous coal from Keystone mine, Stevens Coal Company, Acme, Kanawha County, W. Va., on the Chesapeake and Ohio Railway.

This sample consisted of run-of-mine coal and was loaded under the supervision of Inspector J. W. Groves. It was used in making washing test No. 135, coking tests Nos. 80, 84, 87, and 92, steaming tests Nos. 272 and 273, steaming tests on washed coal Nos. 264 and 266, and producer-gas test No. 82.

Two mine samples were taken in this mine for chemical analysis, as follows: No. 2375 from a point in the left entry 4,600 feet east of the drift mouth; No. 2376 from room 16 off the fifth right entry, 3,500 feet east of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car samples.	
Laboratory number		2375	2376	2556	2626
Air-drying loss		1.40	1.60	2.10	1.90
Proximate.	Moisture	2.66	2.84	2.82	2.89
	Volatile matter	33.30	33.18	32.20	32.53
	Fixed carbon	59.60	58.75	56.95	56.95
	Ash	4.44	5.23	8.03	7.63
	Sulphur	1.14	1.35	1.38	1.50
Ultimate.	Hydrogen	.....	.....	5.16	.....
	Carbon	.....	.....	76.74	.....
	Nitrogen	.....	.....	1.34	.....
	Oxygen	.....	.....	7.35	.....
Calorific value determined:					
	Calories	7,982	.....	7,648	.....
	British thermal units	14,368	.....	13,766	.....

STEAMING TESTS.

Test 272, West Virginia No. 20.

Size as shipped, run of mine. Size as used, over 1 inch, 31.1 per cent; ½ inch to 1 inch, 22.3 per cent; ¼ inch to ½ inch, 19.4 per cent; under ¼ inch, 27.2 per cent. Duration of test, 9.92 hours. Kind of grate, rocking.

Test 273, West Virginia No. 20.

Size as shipped, run of mine. Size as used, over 1 inch, 27.7 per cent; ½ inch to 1 inch, 20 per cent; ¼ inch to ½ inch, 18.5 per cent; under ¼ inch, 33.8 per cent. Duration of test, 9.87 hours. Kind of grate, rocking.

Test 264, West Virginia No. 20, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 23 per cent; ½ inch to 1 inch, 23.7 per cent; ¼ inch to ½ inch, 25.4 per cent; under ¼ inch, 27.9 per cent. Duration of test, 9.97 hours. Kind of grate, rocking.

Test 266, West Virginia No. 20, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 30.9 per cent; ½ inch to 1 inch, 24.4 per cent; ¼ inch to ½ inch, 21.2 per cent; under ¼ inch, 23.5 per cent. Duration of test, 10 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 272.	Test 273.	Test 264.	Test 266.
Heating value of coal.....B. T. U. per pound dry coal..	14,202	14,083	14,584	14,530
Force of draft:				
Under stack damper.....inch water..	0.31	0.40	0.38	0.35
Above fire.....do....	.09	.10	.16	.10
Furnace temperature.....°F..	.....	2,274	2,520	2,392
Dry coal used per square foot of grate surface per hour, pounds.....	15.44	16.57	17.23	15.73
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.80	2.98	3.23	3.09
Percentage of rated horsepower of boiler developed.....	78.5	83.6	90.5	86.7
Water apparently evaporated per pound of coal as fired, pounds.....	8.24	8.13	8.41	7.97
Water evaporated from and at 212° F.:				
Per pound of coal as fired.....pounds..	9.89	9.75	10.09	9.54
Per pound of dry coal.....do....	10.11	10.04	10.46	9.85
Per pound of combustible.....do....	11.21	11.19	11.21	10.56
Efficiency of boiler, including grate.....per cent..	68.75	68.85	69.26	65.47
Coal as fired:				
Per indicated horsepower hour .....pounds..	2.86	2.90	2.80	2.96
Per electrical horsepower hour.....do....	3.53	3.58	3.46	3.66
Dry coal:				
Per indicated horsepower hour .....do....	2.80	2.82	2.70	2.87
Per electrical horsepower hour .....do....	3.45	3.48	3.34	3.55

ANALYSES.

	Test 272.	Test 273.	Test 264.	Test 266.
Proximate.				
Moisture.....	2.21	2.89	3.49	3.14
Volatile matter.....	32.55	31.75	32.94	33.40
Fixed carbon.....	57.31	56.93	58.37	57.93
Ash.....	7.93	8.43	5.20	5.53
	100.00	100.00	100.00	100.00
Sulphur.....	1.28	1.50	1.06	1.10
Ultimate.				
Carbon[a]	79.20	78.49	81.75	81.45
Hydrogen[a]	5.00	4.95	5.17	5.15
Oxygen[a]	5.00	4.97	5.16	5.13
Nitrogen[a]	1.38	1.37	1.43	1.42
Sulphur.....	1.31	1.54	1.10	1.14
Ash.....	8.11	8.68	5.39	5.71
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 82, West Virginia No. 20.

Size as shipped, run of mine. Size as used, not determined. Duration of test, 50 hours.

Average electrical horsepower		196.3
Average B. T. U. gas, per cubic foot		156.3
Total coal fired	pounds	12,150

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 82.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	1.31	1.29	1.19
Developed at switch board	1.24	1.22	1.12
Per brake horsepower:			
Available for outside purposes	1.12	1.09	1.01
Developed at engine	1.05	1.03	0.95
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	1.39	1.36	1.26
Developed at switch board	1.31	1.29	1.19
Per brake horsepower:			
Available for outside purposes	1.18	1.16	1.07
Developed at engine	1.11	1.09	1.01

ANALYSES.

	Test 82.		Test 82.
Coal.		*Gas by volume.*	
Moisture	1.83	Carbon dioxide (CO_2)	8.3
Volatile matter	32.94	Carbon monoxide (CO)	21.0
Fixed carbon	57.63	Hydrogen (H_2)	13.1
Ash	7.60	Methane (CH_4)	2.6
	100.00	Nitrogen (N_2)	55.0
Sulphur	1.71		100.0

WASHING TEST.

Test 135, West Virginia No. 20.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds	49,150
Washed coal	do	42,590
Refuse	do	6,560

ANALYSES.

	Test 135.	
	Raw coal.	Washed coal.
Moisture	2.82	5.70
Volatile matter	32.20	.....
Fixed carbon	56.95	.....
Ash	8.03	4.64
Sulphur	1.38	1.07

COKING TESTS.

Test 80, West Virginia No. 20.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 42 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,385
Breeze produced	do....	262
Coke produced	per cent..	69.88
Breeze produced	do....	2.18
Total percentage yield		72.06

Remarks.—Light gray and silvery. Fine coke. Very heavy. High yield due to deposited carbon.

Test 84, West Virginia No. 20, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 50 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,037
Breeze produced	do....	208
Coke produced	per cent	66.98
Breeze produced	do....	1.73
Total percentage yield		68.71

Remarks.—Light gray and silvery. Breakage badly cross-fractured and irregular, but coke of good foundry size. Results do not warrant washing. Sulphur and ash in coke from raw coal are both low, and coke from washed coal not as good, physically, as that from raw coal.

Test 87, West Virginia No. 20, washed.

Size as shipped, run of mine. Size as used, not crushed. Duration of test, 53 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,893
Breeze produced	do....	302
Coke produced	per cent..	65.78
Breeze produced	do....	2.52
Total percentage yield		68.30

Remarks.—Light gray and silvery. Results, same as in test 84. Do not warrant washing.

Test 92, West Virginia No. 20.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test, 46 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,292
Breeze produced	do....	264
Coke produced	per cent..	69.10
Breeze produced	do....	2.20
Total percentage yield		71.30

Remarks.—Light gray and silvery. Fine coke. Very heavy. High yield due to deposited carbon. Breakage not so good as test 80. Sulphur a little high.

ANALYSES.

	Test 80.		Test 84.		Test 87.		Test 92.	
	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.	Coal.	Coke.
Moisture	3.79	0.17	5.34	0.29	4.47	0.17	3.01	0.18
Volatile matter	32.24	1.08	32.56	0.46	32.79	0.81	32.40	0.57
Fixed carbon	56.49	89.01	57.00	91.73	57.87	92.29	56.60	87.95
Ash	7.48	9.74	5.10	7.52	4.87	6.73	7.99	11.30
Sulphur	1.44	1.10	1.09	0.90	1.02	0.85	1.62	1.30

WEST VIRGINIA NO. 21.

Bituminous coal from Gas mine, Winifrede Coal Company, Winifrede, Kanawha County, W. Va., on the Chesapeake and Ohio Railroad.

This sample consisted of run-of-mine coal, and was loaded under the supervision of Inspector J. W. Groves. The following tests were made: Washing test No. 136, coking tests Nos. 82 and 91, steaming tests Nos. 274, 275, and 296, and steaming test on washed coal No. 267.

Two mine samples were taken from this mine for chemical analysis, as follows: No. 2377 from room 12 off the third left entry, 1,400 feet southeast of the drift mouth; No. 2378 from room 10 off the first left entry, 800 feet southeast of the drift mouth.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		2377	2378	2572
Air-drying loss		2.00	2.30	2.10
Proximate.	Moisture	3.57	3.72	3.57
	Volatile matter	36.76	35.95	36.38
	Fixed carbon	56.05	56.21	55.20
	Ash	3.62	4.12	4.85
	Sulphur	1.14	1.16	1.32
Ultimate.	Hydrogen	.....	.....	5.33
	Carbon	.....	.....	77.49
	Nitrogen	.....	.....	1.49
	Oxygen	.....	.....	9.52
Calorific value determined:				
	Calories	7,874	.....	7,749
	British thermal units	14,173	.....	13,948

STEAMING TESTS.

Test 274, West Virginia No. 21.

Size as shipped, run of mine. Size as used, over 1 inch, 66.3 per cent; ½ inch to 1 inch, 15.7 per cent; ¼ inch to ½ inch, 10.8 per cent; under ¼ inch, 7.2 per cent. Duration of test, 7.30 hours. Kind of grate, rocking.

Test 275, West Virginia No. 21.

Size as shipped, run of mine. Size as used, over 1 inch, 44 per cent; ½ inch to 1 inch, 15.3 per cent; ¼ inch to ½ inch, 11.5 per cent; under ¼ inch, 29.2 per cent. Duration of test, 9.05 hours. Kind of grate, plain.

Test 267, West Virginia No. 21, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 36.2 per cent; ½ inch to 1 inch, 26.6 per cent; ¼ inch to ½ inch, 17.7 per cent; under ¼ inch, 19.5 per cent. Duration of test, 10.02 hours. Kind of grate, plain.

Test 296, West Virginia No. 21.

Size as shipped, run of mine. Size as used, over 1 inch, 40 per cent; ½ inch to 1 inch, 20 per cent; ¼ inch to ½ inch, 14.7 per cent; under ¼ inch, 25.3 per cent. Duration of test, 7.15 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 274.	Test 275.	Test 267.	Test 296.
Heating value of coal.....B. T. U. per pound dry coal..	14,528	14,292	14,791	14,274
Force of draft:				
Under stack damper.....inch water..	0.49	0.54	0.40	0.55
Above fire.....do....	.13	.11	.10	.10
Furnace temperature.....° F..	2,776	2,279	2,476	2,561
Dry coal used per square foot of grate surface per hour, pounds.....	21.59	16.50	16.87	18.13
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	3.99	3.36	3.40	3.63
Percentage of rated horsepower of boiler developed.....	111.9	94.1	95.4	101.8
Water apparently evaporated per pound of coal as fired, pounds.....	8.27	8.23	8.06	8.11
Water evaporated from and at 212 ° F.:				
Per pound of coal as fired.....pounds..	9.94	9.80	9.67	9.69
Per pound of dry coal.....do....	10.31	10.20	10.10	10.03
Per pound of combustible.....do....	10.87	11.05	10.64	10.96
Efficiency of boiler, including grate.....per cent..	68.53	68.92	65.94	67.86
Coal as fired:				
Per indicated horsepower hour.....pounds..	2.85	2.88	2.92	2.92
Per electrical horsepower hour.....do....	3.51	3.56	3.61	3.60
Dry coal:				
Per indicated horsepower hour.....do....	2.74	2.77	2.80	2.82
Per electrical horsepower hour.....do....	3.39	3.42	3.46	3.48

ANALYSES.

	Test 274.	Test 275.	Test 267.	Test 296.
Proximate.				
Moisture.....	3.60	3.90	4.24	3.42
Volatile matter.....	36.30	34.31	36.46	34.26
Fixed carbon.....	55.44	55.75	55.63	56.20
Ash.....	4.66	6.04	3.67	6.12
	100.00	100.00	100.00	100.00
Sulphur.....	1.03	1.13	1.07	1.22
Ultimate.				
Carbon[a].....	80.77	79.43	81.58	79.33
Hydrogen[a].....	5.15	5.06	5.19	5.04
Oxygen[a].....	6.62	6.52	6.72	6.51
Nitrogen[a].....	1.56	1.53	1.56	1.52
Sulphur.....	1.07	1.18	1.12	1.26
Ash.....	4.83	6.28	3.83	6.34
	100.00	100.00	100.00	100.00

[a] Figured from car sample.

WASHING TEST.

Test 136, West Virginia No. 21.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	24,000
Washed coal	do....	22,000
Refuse	do....	2,000

ANALYSES.

	Test 136.	
	Raw coal.	Washed coal.
Moisture	3.57	6.35
Volatile matter	36.38	.....
Fixed carbon	55.20	.....
Ash	4.85	3.47
Sulphur	1.32	1.00

COKING TESTS.

Test 82, West Virginia No. 21.

Size as shipped, run of mine. Size as used, finely crushed. Raw. Duration of test 52 hours.

Coal charged	pounds..	12,000
Coke produced	do....	8,106
Breeze produced	do....	242
Coke produced	per cent..	67.55
Breeze produced	do....	2.02
Total percentage yield		69.57

Remarks.—Fine coke. Light gray and silvery. Very heavy. High yield due to deposited carbon. Good foundry coke.

Test 91, West Virginia No. 21, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 44 hours.

Coal charged	pounds..	12,000
Coke produced	do....	7,816
Breeze produced	do....	249
Coke produced	per cent..	65.13
Breeze produced	do....	2.08
Total percentage yield		67.21

Remarks.—Light gray and silvery. High yield due to deposited carbon. Breakage very irregular, but pieces of good foundry size. Somewhat brittle. Not so good as coke from raw coal. The raw coal and resultant coke are both low in sulphur and ash and washing is of no commercial value.

ANALYSES.

	Test 82.		Test 91.	
	Coal.	Coke.	Coal.	Coke.
Moisture	3.55	0.24	5.72	0.55
Volatile matter	36.32	.81	36.54	1.03
Fixed carbon	55.18	91.23	54.35	93.16
Ash	4.95	7.72	3.39	5.26
Sulphur	1.23	.98	1.01	.76

WYOMING NO. 2.

Bituminous coal from Antelope Nos. 1 and 2 and Jumbo mines, Cambria Fuel Company, Cambria, Weston County, Wyo., on the Burlington system.

This sample consisted of run-of-mine coal and was loaded under the supervision of M. R. Campbell, of the United States Geological Survey. It is designated as Wyoming No. 2 B in the following tests: Steaming tests Nos. 196, 210, and 213, and producer-gas test No. 62.[a]

Two mine samples (Nos. 1376 and 1377) were taken at working faces at widely separated points in the mine.

[a] *For tests of same coal* received during 1904 see Bull. U. S. Geol. Survey No. 261, 1905, pp. 83, 115.

CHEMICAL ANALYSES.

		Mine samples.		Car sample.
Laboratory number		1376	1377	2131
Air-drying loss		4.70	3.80	4.50
Proximate.	Moisture	8.60	9.23	8.93
	Volatile matter	37.13	36.08	36.52
	Fixed carbon	32.37	33.72	33.76
	Ash	21.90	20.97	20.79
	Sulphur	4.94	4.33	4.03
Ultimate.	Hydrogen			4.88
	Carbon			53.33
	Nitrogen			.81
	Oxygen			16.16
Calorific value determined:				
	Calories	5,394		5,556
	British thermal units	9,709		10,001

STEAMING TESTS.

Test 196, Wyoming No. 2 B.

Size as shipped, run of mine. Size as used, over 1 inch, 54.3 per cent; ½ inch to 1 inch, 18.4 per cent; ¼ inch to ½ inch, 14.5 per cent; under ¼ inch, 12.8 per cent. Duration of test, 9.88 hours. Kind of grate, plain.

Test 210, Wyoming No. 2 B.

Size as shipped, run of mine. Size as used, over 1 inch, 34.8 per cent; ½ inch to 1 inch, 21.5 per cent; ¼ inch to ½ inch, 20.4 per cent; under ¼ inch, 23.3 per cent. Duration of test, 10.08 hours. Kind of grate, rocking.

Test 213, Wyoming No. 2 B.

Size as shipped, run of mine. Size as used, over 1 inch, 40.4 per cent; ½ inch to 1 inch, 26.7 per cent; ¼ inch to ½ inch, 15.2 per cent; under ¼ inch, 17.7 per cent. Duration of test, 10.03 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 196.	Test 210.	Test 213.
Heating value of coal.....B. T. U. per pound dry coal..	10,888	11,261	10,751
Force of draft:			
Under stack damper.....inch water..	0.59	0.68	0.63
Above fire.....do....	.19	.20	[a].08
Furnace temperature.....°F..	1,950	2,067	2,228
Dry coal used per square foot of grate surface per hour.....pounds..	22.61	25.66	32.58
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.83	3.15	3.56
Percentage of rated horsepower of boiler developed.....	79.3	88.3	99.86
Water apparently evaporated per pound of coal as fired.....pounds..	4.83	5.30	4.72
Water evaporated from and at 212 °F.:			
Per pound of coal as fired.....do....	5.66	6.19	5.56
Per pound of dry coal.....do....	6.27	6.84	6.10
Per pound of combustible.....do....	8.54	9.01	8.30
Efficiency of boiler, including grate.....per cent..	55.61	58.66	54.79
Coal as fired:			
Per indicated horsepower hour.....pounds..	5.00	4.57	5.09
Per electrical horsepower hour.....do....	6.17	5.64	6.28
Dry coal:			
Per indicated horsepower hour.....do....	4.51	4.13	4.64
Per electrical horsepower hour.....do....	5.57	5.10	5.72

[a] Forced draft.

ANALYSES.

	Test 196.	Test 210.	Test 213.		Test 196.	Test 210.	Test 213.
Proximate.				*Ultimate.*			
Moisture	9.64	9.55	8.94	Carbon [a]	58.01	60.09	57.08
Volatile matter	34.75	35.75	35.90	Hydrogen [a]	4.23	4.39	4.16
Fixed carbon	34.68	35.73	33.70	Oxygen [a]	8.93	9.25	8.80
Ash	20.93	18.97	21.46	Nitrogen [a]	0.89	0.92	0.87
	100.00	100.00	100.00	Sulphur	4.78	4.37	5.52
Sulphur	4.32	3.95	5.03	Ash	23.16	20.98	23.57
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST

Test 62, Wyoming No. 2 B.

Size as shipped, run of mine. Size as used, over 1 inch, 59 per cent; ½ inch to 1 inch, 18 per cent; ¼ inch to ½ inch, 13 per cent; under ¼ inch, 10 per cent. Duration of test, 49 hours.

Average electrical horsepower	192.9
Average B. T. U. gas, per cubic foot	146.6
Total coal fired, pounds	20,400

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 62.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	2.28	2.08	1.59
Developed at switch board	2.16	1.97	1.50
Per brake horsepower:			
Available for outside purposes	1.93	1.77	1.35
Developed at engine	1.83	1.68	1.28
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.40	2.20	1.68
Developed at switch board	2.28	2.09	1.59
Per brake horsepower:			
Available for outside purposes	2.05	1.87	1.43
Developed at engine	1.94	1.77	1.35

ANALYSES.

	Test 62.		Test 62.
Coal.		*Gas by volume.*	
Moisture	8.63	Carbon dioxide (CO_2)	10.8
Volatile matter	36.81	Carbon monoxide (CO)	18.2
Fixed carbon	32.83	Hydrogen (H_2)	10.7
Ash	21.73	Methane (CH_4)	3.3
	100.00	Nitrogen (N_2)	57.0
Sulphur	4.47		100.0

WYOMING NO. 8.

Bituminous coal from mine of Stilwell Coal Company, Aladdin, Crook County, Wyo., on the Wyoming and Missouri Railroad.

This sample consisted of run-of-mine coal and was shipped under the direction of M. R. Campbell, of the United States Geological Survey. The following tests were made: Washing test No. 129, coking test No. 52, steaming tests Nos. 211 and 212, steaming test on washed coal No. 223, and producer-gas test No. 69.

Two mine samples (Nos. 1976 and 1977) for chemical analysis were taken at working faces in the mine.

CHEMICAL ANALYSES.

		Mine samples.		Boiler test sample.
Laboratory number		1976	1977	2278
Air-drying loss		11.80	12.00	2.90
Proximate.	Moisture	17.74	18.42	15.12
	Volatile matter	37.64	36.53	34.36
	Fixed carbon	33.07	34.95	33.82
	Ash	11.55	10.10	16.70
Ultimate.	Sulphur	7.03	6.73	6.66
	Hydrogen	.....	.....	5.20
	Carbon	.....	.....	48.16
	Nitrogen	.....	.....	.70
	Oxygen	.....	.....	22.58
Calorific value determined:				
	Calories	5,293	.....	4,960
	British thermal units	9,527	.....	8,928

STEAMING TESTS.

Test 211, Wyoming No. 3.

Size as shipped, run of mine. Size as used, over 1 inch, 58.7 per cent; ½ inch to 1 inch, 17.3 per cent; ¼ inch to ½ inch, 11.6 per cent; under ¼ inch, 12.4 per cent. Duration of test, 10.05 hours. Kind of grate, rocking.

Test 212, Wyoming No. 3.

Size as shipped, run of mine. Size as used, over 1 inch, 51 per cent; ½ inch to 1 inch, 20.6 per cent; ¼ inch to ½ inch, 12.6 per cent; under ¼ inch, 15.8 per cent. Duration of test, 9.8 hours. Kind of grate, rocking.

Test 223, Wyoming No. 3, washed.

Size as shipped, run of mine. Size as used, over 1 inch, 27.9 per cent; ½ inch to 1 inch, 21.3 per cent; ¼ inch to ½ inch, 20.5 per cent; under ¼ inch, 30.3 per cent. Duration of test, 8.95 hours. Kind of grate, rocking.

MISCELLANEOUS ITEMS.

	Test 211.	Test 212.	Test 223.
Heating value of coal.....B. T. U. per pound dry coal..	10,519	10,517	12,641
Force of draft:			
Under stack damper.....inch water..	0.63	0.45	0.59
Above fire.....do....	.28	a.01	.23
Furnace temperature.....° F..	1,917	2,142	.....
Dry coal used per square foot of grate surface per hour.....pounds..	18.96	26.07	20.0
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.39	3.15	2.89
Percentage of rated horsepower of boiler developed	67.0	88.2	81.0
Water apparently evaporated per pound of coal as fired .....pounds..	5.12	4.95	5.54
Water evaporated from and at 212° F.:			
Per pound of coal as fired.....do....	5.98	5.81	6.53
Per pound of dry coal.....do....	7.04	6.73	8.07
Per pound of combustible.....do....	9.17	8.59	9.96

a Natural and forced draft.

MISCELLANEOUS ITEMS—continued.

	Test 211.	Test 212.	Test 223.
Efficiency of boiler, including grate.....per cent..	64.63	61.80	61.65
Coal as fired:			
Per indicated horsepower hour.....pounds..	4.73	4.87	4.33
Per electrical horsepower hour.....do....	5.84	6.01	5.35
Dry coal:			
Per indicated horsepower hour.....do....	4.02	4.20	3.50
Per electrical horsepower hour.....do....	4.96	5.19	4.33

ANALYSES.

	Test 211.	Test 212.	Test 223.		Test 211.	Test 212.	Test 223.
Proximate.				*Ultimate.*			
Moisture.....	15.12	13.60	19.08	Carbon [a].....	56.73	56.44	67.60
Volatile matter....	34.36	36.12	36.58	Hydrogen [a].....	4.15	4.12	4.94
Fixed carbon.....	33.82	34.07	37.56	Oxygen [a].....	10.77	10.72	12.83
Ash.....	16.70	16.21	6.78	Nitrogen [a].....	0.83	0.82	0.99
	100.00	100.00	100.00	Sulphur.....	7.85	9.14	5.26
Sulphur.....	6.66	7.90	4.26	Ash.....	19.67	18.76	8.38
					100.00	100.00	100.00

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 69, Wyoming No. 3.

Size as shipped, run of mine. Size as used, over 1 inch, 59 per cent; ½ inch to 1 inch, 15 per cent; ¼ inch to ½ inch, 12 per cent; under ¼ inch, 14 per cent. Duration of test, 47 hours.

Average electrical horsepower..... 193.1
Average B. T. U. gas, per cubic foot..... 160.9
Total coal fired.....pounds.. 17,400

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 69.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes.....	2.05	1.78	1.47
Developed at switch board.....	1.92	1.67	1.37
Per brake horsepower:			
Available for outside purposes.....	1.74	1.52	1.25
Developed at engine.....	1.63	1.42	1.17
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes.....	2.19	1.90	1.57
Developed at switch board.....	2.04	1.78	1.46
Per brake horsepower:			
Available for outside purposes.....	1.86	1.62	1.33
Developed at engine.....	1.74	1.51	1.24

ANALYSES.

	Test 69.		Test 69.
Coal.		*Gas by volume.*	
Moisture	13.02	Carbon dioxide (CO_2)	11.1
Volatile matter	37.56	Carbon monoxide (CO)	19.8
Fixed carbon	34.05	Hydrogen (H_2)	13.3
Ash	15.37	Methane (CH_4)	3.5
	100.00	Nitrogen (N_2)	52.3
Sulphur	7.36		100.0

WASHING TEST.

Test 129, Wyoming, No. 3.

Size as shipped, run of mine. Size as used, crushed to 2 inches. Jig used, Stewart modified.

Raw coal	pounds..	24,120
Washed coal	do....	20,060
Refuse	do....	4,060

ANALYSES.

	Test 129.	
	Raw coal.	Washed coal.
Moisture	15.12	19.16
Volatile matter	34.36	.....
Fixed carbon	33.82	.....
Ash	16.70	6.52
Sulphur	6.66	4.16

COKING TEST.

Test 52, Wyoming No. 3, washed.

Size as shipped, run of mine. Size as used, finely crushed. Duration of test, 27 hours.

Remarks.—No coke produced.

ALASKA COAL.[a]

Coal from Bering River field.—The Bering River coal field [b] is located near Controller Bay, on the Pacific coast of Alaska, in latitude 60° 20′ to 60° 30′ N. and longitude 143° 15′ to 144° 45′ W., and covers an area of about 70 square miles, including 25 square miles of anthracite and 45 miles of semibituminous coking coal. The seams are numerous and very large (several exceeding 20 feet in thickness). The average quality of the Bering River coal is excellent, several of the seams being remarkably low in both ash and sulphur.

This coal is not now available for sale in any market, but there are prospects of transportation soon being provided to tide water on Controller Bay, Katalla Bay, or Prince William Sound.

Coal from Matanuska River field.—The Matanuska coal field [c] is located about 30 to 75 miles northeast of Cook Inlet, Alaska, in latitude 61° 40′ to 62° N. and longitude 148° to 149° 10′ W., and covers an area of at least 70 and possibly several hundred square miles of coal in the Matanuska Valley. The deposits include anthracite, semibituminous coking coal, and a lower grade of bituminous coal. The seams are of good thickness and well situated for mining. Transportation to Resurrection Bay on the Pacific coast and into the interior may soon be provided by the Alaska Central Railway, now under construction.

[a] The analyses given herein are all of field samples collected by Mr. G. C. Martin.

[b] See Martin, G. C., Bull. U. S. Geol. Survey No. 225, 1904, pp. 365-382; No. 250, 1905, pp. 11-36; No. 259, 1905, pp. 140-150; No. 284, 1906, pp. 65-77.

[c] See Martin, G. C., Bull. U. S. Geol. Survey No. 284, 1906, pp. 88-100; No. 289, 1906.

CHEMICAL ANALYSES.

BERING RIVER COALS.

Laboratory number	2490	2488	2493	2495	2486	2492	2491
Thickness of coal seam, feet	6.7	10	8.6	31	27	11	19.6
Air-drying loss, per cent	3.70	5.20	5.10	4.60	3.00	3.70	5.40
Moisture, do	4.35	6.03	5.84	5.66	4.23	4.22	5.95
Volatile matter, do	11.97	12.98	11.74	13.65	14.03	13.37	13.01
Fixed carbon, do	73.34	78.40	60.21	76.81	79.75	78.80	76.12
Ash, do	10.34	2.59	22.21	3.88	1.99	3.61	4.92
Sulphur, do	1.13	.70	3.36	.77	.96	1.56	.61

Laboratory number	2494	2497	2489	2496	2487	2485	2478
Thickness of coal seam, feet	17	18	8	15	4.7	2.17	2.67
Air-drying loss, per cent	3.90	1.90	1.30	5.20	6.20	1.90	4.70
Moisture, do	4.94	2.68	2.11	5.93	7.26	3.74	7.67
Volatile matter, do	13.34	11.06	16.58	6.76	6.64	5.41	5.78
Fixed carbon, do	77.29	73.31	79.68	81.47	75.89	85.92	66.03
Ash, do	4.43	12.95	1.63	5.84	10.21	4.93	20.52
Sulphur, do	.83	5.27	.78	.82	1.27	1.10	2.90

No. 2490. Opening at lower end of gorge on Tokun Creek.
No. 2488. Christopher's opening on branch of Dick Creek.
No. 2493. Christopher's lower tunnel, Dick Creek.
No. 2495. Opening on lower seam, Queen Creek.
No. 2486. Opening on upper seam, Queen Creek.
No. 2492. Carbon Creek tunnel.
No. 2491. Tunnel near mouth of Carbon Creek.
No. 2494. South branch of Queen Creek.
No. 2497. Kushtaka River, tunnel 710 feet above Lake Kushtaka.

Laboratory number	2479	2480	2481	2482	2483	2484
Thickness, feet	2.85	15+	5.25	10	10.5	33
Air-drying loss, per cent	1.50	6.10	5.00	7.00	13.20	5.40
Moisture, do	4.43	8.33	7.94	8.31	13.89	6.34
Volatile matter, do	10.14	6.36	9.20	7.12	5.01	14.29
Fixed carbon, do	80.78	82.00	78.53	82.43	73.87	69.55
Ash, do	4.65	3.31	4.33	2.14	7.23	9.82
Sulphur, do	.51	1.11	.79	1.05	.82	.64
Calories	7,578	.....	.....	.....	6,743	.....
British thermal units	.....	.....	.....	.....	12,137	.....

No. 2489. Cunningham's upper tunnel, Trout Creek; tunnel across from house.
No. 2496. Opening at north end of Hunt's hillside trail, Carbon Mountain.
No. 2487. Lower seam east side Carbon Mountain.
No. 2485. Gulch at head of First Berg Lake, Carbon Mountain.
No. 2478. Gulch at head of Fourth Berg Lake, Carbon Mountain.
No. 2479. Near crest (west side) of Carbon Mountain, between trails.
No. 2480. Eastern opening, hillside trail, east side of Carbon Mountain.
No. 2481. Crest of Carbon Mountain, 50 feet above sample No. 2479, between Hunt's and Green's trails.
No. 2482. South end of hillside trail, west side of Carbon Mountain.
No. 2483. Western opening, hillside trail, east side of Carbon Mountain.
No. 2484. Trout Creek tunnel, one-fourth mile below house.

MATANUSKA COALS.

Laboratory number	2217	2221	2225	2226	2223	2214	2216
Thickness of coal seam ....feet..	5	11.7	6	2.6	1	7	7
Air-drying loss....per cent..	0.80	4.60	(a)	(a)	(a)	1.60	1.00
Moisture....do....	2.24	10.05	4.03	5.56	2.50	4.36	2.46
Volatile matter....do....	23.08	36.05	34.84	36.52	28.32	18.92	17.01
Fixed carbon....do....	70.21	48.90	49.31	51.32	58.82	61.19	53.23
Ash....do....	4.47	5.00	11.82	6.60	10.36	15.53	27.30
Sulphur....do....	.50	.25	.38	.42	.58	.37	.84

Laboratory number	2215	2218	2219	2220	2222	2224	2227
Thickness of coal seam ....feet..	12.3	9.9	8.6	7.9	38	3.3	5.2
Air-drying loss....per cent..	1.60	1.80	4.10	1.90	(a)	(a)	(a)
Moisture....do....	2.58	2.93	6.74	2.90	2.55	6.60	0.90
Volatile matter....do....	19.14	21.85	14.96	17.47	7.08	34.30	19.60
Fixed carbon....do....	67.46	63.09	65.83	56.15	84.32	48.23	74.60
Ash....do....	10.82	12.13	12.47	23.48	6.05	10.87	4.90
Sulphur....do....	.57	.59	.44	.46	.57	.41	.60
Calories....	.....	.....	6,649	.....	7,617	6,299	8,260

[a] Sample too small to be air dried accurately.

No. 2217. Coal Creek, three-fourths mile above Matanuska River.
No. 2221. Tsadaka Creek, 4½ miles above trail.
No. 2225. Tsadaka Creek, 4 miles above trail.
No. 2226. West bank of Eska Creek, 3 miles above trail.
No. 2223. West bank of Young Creek, 3 miles above trail.
No. 2214. South bank of Matanuska River, 3 miles above mouth of Chickaloon Creek.
No. 2216. Watson's tunnel No. 3, Chickaloon Creek.
No. 2215. Watson's tunnel No. 2, Chickaloon Creek.
No. 2218. West bank of Kings Creek, at upper bridge.
No. 2219. Coal Creek, three-fifths mile above Matanuska River. Sample package not sealed.
No. 2220. Watson's tunnel No. 5, Chickaloon Creek.
No. 2222. Matanuska Valley (north side) between Boulder and Hicks creeks, about 18 miles from Chickaloon Creek. Small sample.
No. 2224. Eska Creek, 3 miles above trail.
No. 2227. Watson's tunnel No. 2, Chickaloon Creek.

BRAZIL NO. 1.

Run-of-mine coal from mines near Sao Jeronymo, about 30 miles west of Porto Alegre, in the state of Rio Grande do Sul, Brazil. The bed has a thickness of nearly 6 feet and is usually separated into two nearly equal portions by a stratum of black clay or slate, which varies from 4 inches to 2 feet or more in thickness. The rocks which hold the Brazil coal consist of alternate layers of gray sandstones and shales having a thickness of 300 to 400 feet. The flora found in connection with them appears to place them at the very top of the Carboniferous beds, either in the Permian or "Permo-Carboniferous." The bed from which this sample was taken occurs near the summit of the coal-bearing series. It is found over a wide area in the state of Rio Grande do Sul and appears to extend northward through the state of Santa Catharina, where it has been mined in the Tubarao district.

This sample was supplied by the Brazilian Government through Dr. I. C. White, State geologist of West Virginia, and was tested to furnish data that will serve as a basis for an investigation of coals now undeveloped in West Virginia and other States, which are similar in character and geologic age.

STEAMING TESTS.

Test 172, Brazil No. 1.

Size as used (average diameter), 1.42 inches. Duration of test, 5.35 hours. Kind of grate, plain.

Test 173, Brazil No. 1.

Size as used (average diameter), 1.26 inches. Duration of test, 5.00 hours. Kind of grate, plain.

MISCELLANEOUS ITEMS.

	Test 172.	Test 173.
Heating value of coal.....B. T. U. per pound dry coal..	10,028	9,830
Force of draft:		
Under stack damper.....inch water..	0.65	0.59
Above fire.....do....	.16	[a].03
Furnace temperature.....°F..	1,900	1,858
Dry coal used per square foot of grate surface per hour.....pounds..	22.61	24.93
Equivalent water evaporated per square foot of water-heating surface per hour.....pounds..	2.62	3.03
Percentage of rated horsepower of boiler developed.....	73.38	85.0
Water apparently evaporated per pound of coal as fired.....pounds..	4.48	4.67
Water evaporated from and at 212° F.:		
Per pound of coal as fired.....do....	5.16	5.43
Per pound of dry coal.....do....	5.80	6.09
Per pound of combustible.....do....	8.43	8.94
Efficiency of boiler, including grate.....per cent..	55.85	59.02
Coal as fired:		
Per indicated horsepower hour.....pounds..	5.48	5.21
Per electrical horsepower hour.....do....	6.77	6.43
Dry coal:		
Per indicated horsepower hour.....do....	4.88	4.64
Per electrical horsepower hour.....do....	6.02	5.73

[a] Forced.

ANALYSES.

	Test 172.	Test 173.		Test 172.	Test 173.
Proximate.			*Ultimate.*[a]		
Moisture	10.92	10.87	Carbon	56.70	55.23
Volatile matter	27.06	26.00	Hydrogen	3.71	3.61
Fixed carbon	37.49	38.32	Oxygen	8.08	7.86
Ash	24.53	24.81	Nitrogen	.95	.93
	100.00	100.00	Sulphur	3.02	4.53
Sulphur	2.69	4.04	Ash	27.54	27.84

[a] Figured from car sample.

PRODUCER-GAS TEST.

Test 44, Brazil No. 1.

Duration of test, 24 hours.

Average electrical horsepower	141.8
Average B. T. U. gas, per cubic foot	130.9
Total coal fired, pounds	8,100

COAL CONSUMED IN PRODUCER (POUNDS PER HORSEPOWER PER HOUR).

	Test 44.		
	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower:			
Available for outside purposes	2.63	2.35	1.73
Developed at switch board	2.38	2.12	1.56
Per brake horsepower:			
Available for outside purposes	2.24	1.99	1.47
Developed at engine	2.02	1.80	1.33
Equivalent used by producer plant.			
Per electrical horsepower:			
Available for outside purposes	2.88	2.56	1.89
Developed at switch board	2.60	2.32	1.71
Per brake horsepower:			
Available for outside purposes	2.45	2.18	1.61
Developed at engine	2.21	1.97	1.45

ANALYSES.

	Test 44.		Test 44.
Coal.		*Gas by volume.*	
Moisture	10.96	Carbon dioxide (CO_2)	11.5
Volatile matter	26.78	Carbon monoxide (CO)	15.9
Fixed carbon	38.82	Hydrogen (H_2)	10.8
Ash	23.44	Methane (CH_4)	2.9
	100.00	Nitrogen (N_2)	58.8
Sulphur	2.94	Oxygen (O_2)	.1
			100.0

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[Bulletin No. 290.]

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CHARLES D. WALCOTT, DIRECTOR

A

GAZETTEER OF COLORADO

BY

HENRY GANNETT

WASHINGTON
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1906

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A GAZETTEER OF COLORADO.

By HENRY GANNETT.

GENERAL DESCRIPTION.

Colorado is situated about midway the country north and south, and about two-thirds of the distance from the Atlantic to the Pacific coast. On the north are Wyoming and Nebraska, on the east Nebraska and Kansas, on the south New Mexico, and Utah on the west. The State is a quadrilateral in shape, its north and south boundaries being respectively the forty-first and thirty-seventh parallels of latitude; its east boundary is the meridian of 25° west of Washington, and its west boundary that of 32°. Thus its length from north to south is 4° of latitude or 276 miles, and its breadth from east to west is 7° of longitude. The length of its north boundary is 366 miles, and of its south boundary 387 miles. The gross area of the State, as computed by square degrees, is 103,948 square miles. Deducting a few small lakes and other bodies of water leaves 103,658 square miles of land area.

TOPOGRAPHY.

In general terms, the eastern third of Colorado is composed of high plains, the middle third of the Rocky Mountains, and the western third of plateaus stepping down toward Colorado River. The Rocky Mountains form a complex system not easily analyzed. They rise from the highest part of the Cordilleran Plateau, and in this State attain their greatest altitude. The most eastern range, known as the "Front Range," enters the State from Wyoming on the north, and extending southward terminates in Pikes Peak. The rise from the east is in long spurs stretching from 10 to 30 miles from the summits to the plains along the base. The plains range from 6,000 to 8,000 feet in altitude, while the summits throughout the greater part of its length exceed 13,000 feet, and there are many peaks higher than 14,000 feet. Among these are Longs, 14,271 feet; Grays, 14,341 feet; Torrey, 14,336 feet; and Pikes, 14,107 feet.

West of the Front Range is the Park Range, which also enters the State from Wyoming, and running nearly south terminates in about the same latitude. In the northern part of the State this is the westernmost range of the system, and from its western flanks the plateaus descend in series toward Green River. This range is but slightly inferior in height to the Front Range, containing several peaks exceeding 14,000 feet, among which are Quandary, 14,266; Lincoln, 14,297 feet; Bross, 14,100 feet; and Sheridan, 14,038 feet.

Between the Front and Park ranges is a series of high mountain valleys extending from north to south, separated by high cross ranges. The most northerly of these is North Park, in which rises North Platte River. It is mainly a level expanse with an average elevation of 8,000 feet. South of it is Middle Park, in which heads Grand River, which flows westward across the park and cuts a gap (Gore Canyon)

through the Park Range on its way to join Green River, forming the Colorado. Middle Park consists mainly of secondary ranges of mountains and hills, alternating with broad valleys. The altitude differs greatly in different parts, but it is generally less than that of North Park. The third is South Park, in the northwestern part of which heads South Platte River, which traverses it in a southeasterly direction. South Park is the highest of the three, its altitude ranging from 8,000 to 10,000 feet. It is generally very level.

West of South Park and of the southern portion of the Park Range, Arkansas River heads in Tennessee Pass; and beyond, forming the west wall of Arkansas Valley, is the Sawatch Range. This is a high, broad and massive range with many peaks exceeding 14,000 feet. At the north is the Mountain of the Holy Cross, with a height of 14,170 feet; then follow Massive, 14,424 feet; Elbert, 14,421 feet; La Plata, 14,342 feet; Harvard, 14,375 feet; Yale, 14,187 feet; and Princeton, 14,196 feet.

West of the Sawatch Range is a succession of high ranges and more or less isolated mountains, known collectively as the "Elk Mountains" or the "Gunnison Country," and beyond them are the plateaus.

Returning to the eastern part of the mountain region we find facing the plains the Sangre de Cristo Range, which stretches from Arkansas River south into New Mexico. This is a narrow ridge of great altitude, with a number of peaks exceeding 14,000 feet, and only two passes lower than 10,000 feet. On the north near Arkansas River is a high range known as the "Wet Mountains," standing as an outlier east of the Sangre de Cristo Range.

West of the Sangre de Cristo Range is the great San Luis Valley, which extends nearly from Arkansas River into New Mexico. Its surface is extremely level and ranges in altitude from 7,000 to 8,000 feet. West of San Luis Valley rise the San Juan Mountains in which head Rio Grande, flowing into the Gulf of Mexico, the San Juan flowing westward to the Colorado, and many branches of Grand and Gunnison rivers. In this group are many peaks exceeding 14,000 feet. Among them are Handies, 14,008 feet; Sneffels, 14,158 feet; Wilson, 14,250 feet; Eolus, 14,079 feet; Sunlight, 14,053 feet; Windom, 14,084 feet; and Uncompahgre, 14,289 feet.

The plains rise from an altitude of 3,000 or 4,000 feet at the east boundary of the State to 6,000 or 8,000 at the foot of the mountains. Their surface is rolling and in some places broken. At the foot of the mountains the stratified beds are tilted up, forming hogbacks, which run in long, regular lines parallel to the base of the mountains.

Within the mountains head North Platte, South Platte, and Arkansas rivers. The first flows northward into Wyoming, while the South Platte and Arkansas, after forcing their way through numerous ridges and spurs, enter the plains. The South Platte pursues in the plains a course nearly north and then northeast, finally uniting with North Platte River at the town of North Platte, in Nebraska. The Arkansas after reaching the plains pursues a course nearly east to the eastern boundary of the State. Except near the mountains the plains contain few perennial streams; indeed, water is very scarce except immediately after rains.

From the westernmost of the mountain ranges the country descends in a series of plateaus, some of which are horizontal and others inclined at different angles and in various directions. Most of the streams, whether perennial or not, are in canyons cut to varying depths. This plateau region is drained entirely by tributaries of Colorado River. The higher of these plateaus are well watered and covered with forests, but as one descends the region become more desert-like, the lowest parts of the plateau having all the aspects of a desert.

Colorado has the highest average elevation of all the States—6,800 feet. The following table classifies the areas by altitude:

Elevations in Colorado.

From—	Square miles.	From—	Square miles.
3,000 to 4,000 feet	4,900	7,000 to 8,000 feet	13,500
4,000 to 5,000 feet	22,700	8,000 to 9,000 feet	11,500
5,000 to 6,000 feet	17,100	9,000 to 10,000 feet	8,600
6,000 to 7,000 feet	12,725	Above 10,000 feet	12,900

The principal rivers are North Platte, South Platte, Arkansas, Rio Grande, Yampa, White, Grand, Gunnison, Dolores, and San Juan. None of these streams are navigable. They head in the mountains, and with steep and rugged courses flow to the plains or plateaus. These rivers, with their numerous branches in the mountain country of Colorado, probably furnish a more abundant supply of water for irrigation purposes than the streams of any other State in the arid region. Most of them are drawn upon heavily in aid of irrigation.

CLIMATE.

Although Colorado is greatly elevated above sea level, the lowest portion along the east boundary being 3,000 feet in altitude, the temperature is but slightly lower than in regions of the same latitude near sea level, because the isothermal lines are carried up by the great mass of country. The mean annual temperature of the plains and plateaus ranges from 45° to 55°, while that of the higher mountain valleys or parks is 40° or even less, and upon the mountain ranges it is still lower.

The range of temperature between day and night, between summer and winter, and between the highest and lowest temperatures recorded, is very great, far greater than in the Mississippi Valley or on the Atlantic coast. Thus the difference between the temperatures of the coldest and warmest months is, on an average, not far from 50°. Upon the plains, at such points as Denver and Colorado Springs, the temperature frequently falls below zero in winter, while summer temperatures above 100° are often recorded, and on the low plateaus in the western part the range of temperature is even greater.

Colorado lies within the arid region. The plains to the east of the mountains and the plateaus to the west have an annual rainfall of less than 20 inches, decreasing in some localities, especially in the western part, to 10 inches or even less. In the mountains the rainfall is greater, exceeding 30 inches. The distribution of rainfall throughout the year is peculiar to the Rocky Mountain region; instead of falling mainly in the winter time, as is the case on the Pacific coast, the summer is the rainy season, and instead of long storms the rain comes in the form of showers. At Denver five-sixths of the annual precipitation falls from May to October, inclusive, and in other parts of the State the proportion in these months is from two-thirds to nine-tenths of the total annual precipitation. The cause of this phenomenon is that in winter the ranges bordering the Pacific (this ocean being the source of precipitation for the entire western country) take practically all the moisture from the vapor-laden winds coming off that ocean, while in summer, owing to the fact that these ranges are relatively warmer, a part of the moisture is carried over to the interior country. The aridity of the region is shown not only in the light rainfall, but in the relative humidity of the atmosphere. On the plains and plateaus the average relative humidity is not far from 50 per cent—that is, the air contains on an average only about one-half the moisture which it is possible for it to absorb.

HISTORY.

The eastern part of Colorado was a part of the Louisiana Purchase acquired from France in 1803; a narrow strip across the center from north to south was a part of the Texas Acquisition; while the western part was from the Mexican Cession under the treaty of Guadalupe Hidalgo.

The Territory of Colorado was organized February 28, 1861, from parts of Kansas, Nebraska, Utah, and New Mexico, and was admitted as a State on August 1, 1876. The region which is now Colorado was inhabited by the Ute tribe of Indians when first known to white men. Their homes were in the mountains, while the plains, then swarming with buffalo, were the common hunting grounds for this and other tribes. The first white settlers were of Spanish blood and entered from New Mexico at an early date. Their descendants still form an important element in the population of the southern part of the State. The first American immigration commenced about 1860, and was induced by the discovery of gold placers in South Park and in the Arkansas Valley to the west. From that time the population of Colorado has increased rapidly, as is shown by the following table:

Population by censuses, 1860–1900.

Census.	Population.	Increase.	Census.	Population.	Increase.
		Per cent.			*Per cent.*
1860	34,277	.....	1890	412,198	112.1
1870	39,864	16.3	1900	539,700	30.7
1880	194,327	387.5	1903 (estimated)	574,030	.....

The population in 1905 was probably not far from 600,000.

The males were in excess, there being in 1900, 295,332 males to 244,386 females; or of the entire population, 55 per cent were males and 45 per cent females.

The number of foreign born were 91,155, or 17 per cent; while the native born were 448,545, or 83 per cent, of the entire population.

The following table shows the distribution by race, in which it appears that 98 per cent of the population were white, 1.6 per cent negro, and the remaining 0.4 per cent Indians, Japanese, and Chinese:

Population by race in 1900.

Race.	Number.	Race.	Number.
White	529,046	Indian	1,437
Negro	8,570	Chinese and Japanese	647

The literacy of the people of Colorado is high. Of the population 10 years of age and over, only 4.2 per cent were unable to read and write. In this Colorado is exceeded by only nine of the States and Territories.

The following are the chief cities with their population in 1900 and the estimated population in 1903:

Population of principal cities.

City.	1900.	1903.	City.	1900.	1903.
Denver	133,859	144,588	Cripple Creek	10,147	7,000
Pueblo	28,157	29,237	Boulder	6,150	.....
Colorado Springs	21,085	24,092	Trinidad	5,345	.....
Leadville	12,455	13,076			

AGRICULTURE.

Of the four great branches of industry, namely, agriculture, manufacture, mining, and transportation, the most important, as measured by the value of its product, is mining, while agriculture and manufacture follow closely.

Owing to the location of the State within the arid region, agriculture is in large part limited by the supply of water for irrigation. It is true that in some localities, which by reason of local topography enjoy an unusual rainfall, dry farming is carried on. The total number of farms in the State in 1900 was 24,700, and their total value was $161,045,101. This value was made up of four items, as follows: Land and improvements, $90,341,523; buildings, $16,002,512; implements and machines, $4,746,755; live stock, $49,954,311. The average value per farm was $6,520. The value of all farm products in 1900 was $33,048,576, an average per farm of $1,338. The value of farm products averaged about 20 per cent of the capital invested in farms.

In the farms of Colorado there are 9,474,588 acres, of which 2,273,968 acres or 24 per cent were improved or cultivated. This cultivated area is only 3.4 per cent of the entire area of the State, and yet it is a larger proportion than in any other State in the arid region. The average number of acres per farm was 384, which is more than twice the size of the average farm in the United States. About 77 per cent of all farms were owned by their occupants, 14 per cent being rented on shares, and 9 per cent rented for cash. Of the cultivated land, 1,611,271 acres or 71 per cent were under irrigation. The area irrigated was 2.4 per cent of the total area of the State.

The following table shows the production of the principal crops and the enumeration of live stock in 1900:

Statistics of farm products and of live stock in 1900.

	Production.		Number.
CROP.		LIVE STOCK.	
Wheat.....bushels..	5,587,770	Neat cattle.....	1,433,318
Potatoes.....do....	4,465,748	Horses.....	236,546
Oats.....do....	3,080,130	Mules.....	6,784
Corn.....do....	1,275,680	Sheep.....	2,044,814
Hay and forage.....tons..	1,647,321	Swine.....	101,198

The value of all domestic animals in 1900 was $49,359,781, and the value of animals sold in 1899, $9,570,952.

MANUFACTURES.

Manufactures are assuming great proportions in Colorado. In 1900 there were 3,570 manufacturing establishments of all kinds, with a capital of $62,825,472. They employed 24,725 wage-earners and paid them $15,146,667. The cost of the materials used was $66,886,016 and the value of the production $102,830,137, showing a net increase in value produced by manufacture of $35,944,121. This figure, which measures the importance of the manufactures, is slightly in excess of the value of agriculture.

The following table gives the number of establishments and the gross value of their product, including custom work and repairing, of a few of the most important industries.

Statistics of manufactures.

Industry.	Number.	Value of product.
Flouring and grist mills	60	$4,528,062
Printing and publishing plants	278	3,561,754
Foundries and machine shops	77	3,986,915
Car and general construction shops	60	3,141,602
Sawmills	159	1,627,605

MINING.

In its mines Colorado finds its chief source of wealth. In 1902 the output of these mines had a value of $40,603,286, being exceeded only by Pennsylvania, Ohio, Michigan, and West Virginia. Of all the Western States and Territories Colorado is easily first in production. It produced the largest amount of gold and silver; was third in the production of lead, being exceeded by Idaho and Utah; was fourth in the production of zinc, and sixth in the production of copper; in the production of coal it was exceeded by seven States, and in petroleum by eleven. The following table shows the quantity and value of its principal products in 1904:

Mineral production in 1904.

Product.	Quantity.	Value.	Product.	Quantity.	Value.
Gold .....fine ounces..	1,183,518	$24,463,322	Coal .....short tons..	6,658,355	$8,751,821
Silver .....do....	13,947,635	7,985,028	Zinc .....do....	4,871	[a]487,100
Copper .....pounds..	9,506,944	1,188,368	Iron ore .....long tons..	150,972	429,856
Lead .....short tons..	51,884	[a]4,410,140	Petroleum .....barrels..	501,863	578,035

[a] Estimated.

TRANSPORTATION.

In 1904 Colorado contained 4,976 miles of railway, which is 2.33 per cent of the entire mileage of the United States.

EXPLORATION AND MAPPING.

The exploration of Colorado began in 1807, when Capt. Zebulon M. Pike, of the United States Army, crossed the plains and followed the Arkansas River to the present site of Pueblo, arriving there in early winter. From this point he attempted to climb Pikes Peak, but abandoned it after several days' struggle with deep snow, remarking that only a bird could reach the summit, yet there is now a cogwheel railroad to the top of the mountain and thousands of people visit it every summer. The next few months were devoted to an attempt to explore the hills north of the Canyon of the Arkansas bordering South Park on the south, in which work he and his men suffered extremely from cold. Toward spring they crossed Sangre de Cristo Range into San Luis Valley, where, being in Mexican territory, they were captured by a detachment of Mexican troops and taken to Santa Fe. After a period of detention they were released and returned to the United States.

During the following years many expeditions, under Fremont, Long, and others, traversed the plains in various directions. In 1840–45 Fremont explored the mountain regions, and in 1853 Captain Gunnison, commanding one of the Pacific Railroad expeditions, traversed the State from east to west by way of the Arkansas, *San Luis, Gunnison, and* Grand River valleys. Several other army expeditions

explored parts of the State, so that in its broader aspects the topographic features were pretty well known at the beginning of the American settlements. In 1870 and 1871 the Fortieth Parallel Survey mapped a strip of country between 40° 30′ and 41° in latitude and extending across the mountain and plateau portions. Between 1873 and 1876 the Hayden Survey mapped, on a scale of 4 miles to an inch and with contour intervals of 200 feet, that part of the State lying west of longitude 104° 30′, including all the mountain and plateau regions. This Survey published a topographic and geologic atlas of the State, which in subsequent years had a powerful influence in its development. Since the commencement of topographic work by the present Geological Survey much detailed work has been done, 34 sheets upon a scale of 1:125,000 and 18 sheets upon a scale of 1:62,500 having been prepared. The total area surveyed is in the neighborhood of 38,000 square miles, or considerably more than one-third of the total area.

There are 14 forest reserves in the State, comprising most of the mountain and plateau country. The total area of land thus reserved is 18,236 square miles, or 17 per cent of the total area.

GAZETTEER.

Atlas sheet.

Abbey; post village in Pueblo County ..... Pueblo.

Abbeyville; village in Gunnison County; altitude, 9,806 feet.

Abbott; post village in Washington County.

Aberdeen; village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,938 feet.

Aberdeen Junction; station in Gunnison County on Colorado Midland Railway; altitude, 7,540 feet.

Aboroto; creek in Hinsdale County, a right-hand branch of Rio Piedra, tributary to San Juan River.

Abrams; mountain in San Juan Mountains on boundary between Ouray and San Juan counties ..... Silverton.

Acequia; station in Douglas County on the Denver and Rio Grande and the Atchison, Topeka and Santa Fe railways; altitude, 5,516 feet..... Denver.

Acme; station in Las Animas County on Colorado and Southern Railway; altitude, 6,314 feet.

Ada Spring; village in Larimer County; altitude, 9,279 feet.

Adair; station in Las Animas County on Colorado and Southern Railway; altitude, 5,754 feet ..... Elmoro.

Adair; summit in Las Animas County; altitude, 5,968 feet.... Elmoro.

Adamans; gulch in Jefferson and Park counties, tributary to South Platte River..... Pikes Peak.

Adams; village in Larimer County.

Adams; county in the northeastern part of the State; bounded on the north by Weld and Morgan counties, on the east by Washington County, on the south by Arapahoe County, and on the west by Jefferson and Boulder counties. The surface consists of rolling plains and is traversed by many dry water courses. The area is 1,253 square miles, of which a considerable area in the western portion is under cultivation where the Union Pacific Railroad and the Burlington Route cross the county. As this county has been formed since 1900 from Arapahoe County, it is impossible to give its population or percentage of cultivated area. The county seat is Brighton, a town of about 366 inhabitants, while the next town in size is Harris, which had, in 1900, a population of 127. In 1900 the average magnetic declination was 12° 45′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 45° to 50°.

Adana; station in Prowers County on Atchison, Topeka, and Santa Fe Railway; altitude, 3,474 feet ..... Granada.

Atlas sheet.

Adelaide; station in Fremont County on Florence and Cripple Creek Railroad; altitude, 6,938 feet ..... Pikes Peak.
Adobe; buttes in Delta County.
Adobe; creek in Fremont County, a left-hand branch of Hardscrabble Creek, tributary to Arkansas River ..... Canyon City.
Adobe; creek in Lincoln County, a left-hand branch of Arkansas River. { Arroyo. / Las Animas.
Adobe; station in Fremont County on Denver and Rio Grande Railroad ..... Canyon City.
Afley; peak in Gunnison County ..... Anthracite.
Agate; creek, a right-hand branch of South Platte River.
Agate; post village in Elbert County on Union Pacific Railroad; altitude, 5,457 feet ..... Limon.
Agency; peak in Saguache County; altitude, 12,274 feet.
Agency Park; valley in Rio Blanco County on White River, in which was formerly located the White River Indian Agency, now the town of Meeker; altitude, 6,491 feet.
Aguilar; post city in Las Animas County on a spur of Colorado and Southern Railway; population in 1900, 698 ..... Spanish Peaks.
Ajax; village in Teller County on Florence and Cripple Creek Railroad.
Akin; station in Mesa County on Denver and Rio Grande Railroad.
Akron; post town and county seat of Washington County on Burlington and Missouri River Railroad; population in 1900, 351; altitude, 4,669 feet.
Alamosa; post town in Conejos County on Denver and Rio Grande Railroad; population in 1900, 1,141; altitude, 7,536 feet.
Alamosa; creek, a right-hand branch of Rio Grande.
Albano; post village in El Paso County.
Albany; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.
Albany; post village in Prowers County ..... Albany.
Albany; village in Ouray County.
Alcott; village in Denver County.
Alden; creek in Gunnison County, a right-hand branch of Tomichi Creek, tributary to Gunnison River.
Alder; creek, a right-hand branch of San Miguel River.
Alder; post village in Saguache County on Denver and Rio Grande Railroad; altitude 8,677 feet. Railroad name, Round Hill.
Alfalfa; post village in Las Animas County.
Alford; post village in Larimer County.
Alicante; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,160 feet.
Alice; post village in Clear Creek County.
Alkali; arroyo in Las Animas County, a right-hand branch of Purgatory River.
Alkali; creek in Gunnison County, a right-hand branch of Taylor River, tributary to Gunnison River.
Alkali; creek in Gunnison County, a left-hand branch of Cow Creek, tributary to Uncompahgre River ..... Ouray.

Atlas sheet.

Alkali; creek in Montrose County, a left-hand branch of Smiths Fork.
Alkali; gulch in La Plata County, tributary to Cherry Creek.. La Plata.
Alkali; gulch in Montezuma County, tributary to McElmo Creek.
Alkali; lake in Park County.
Alkali; springs in Las Animas County.
Allen; creek, a right-hand branch of Tarryall Creek.
Allen Park; post village in Boulder County.
Allenton; station in Eagle County on Denver and Rio Grande Railroad; altitude, 7,134 feet. Post-office, Edwards.
Allison; post village in La Plata County.
Alma; post village in Park County on Colorado and Southern Railway; population in 1900, 297; altitude, 10,238 feet.... Leadville.
Almont; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,031 feet.
Alnwick; village in Teller County ..... Pikes Peak.
Alpine; gulch in Hinsdale County, tributary to Henson Creek. Lake City.
Alpine; pass over Sawatch Range, between Chaffee and Gunnison counties.
Alpine; peak in Front Range in Clear Creek County; altitude, 11,525 feet ..... Georgetown.
Alpine; plateau in Gunnison County sloping northward from the summits of San Juan Mountains toward the Gunnison River..... Lake City.
Alpine; station in Chaffee County on Colorado and Southern Railway.
Alpine; tunnel in Gunnison County on Colorado and Southern Railway; altitude, 11,606 feet.
Alps; hill in Gilpin County ..... Central City Special.
Alps; mountain in Clear Creek County; altitude, 10,508 feet.. Georgetown.
Alps Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,328 feet.
Alta Basin; cirque in Silver Mountain, San Miguel County .. Telluride.
Alta Vista; station in Teller County on Florence and Cripple Creek Railroad; altitude, 9,703 feet.
Altman; post town in Teller County on Florence and Cripple Creek Railroad; population in 1900, 659; altitude, 10,786 feet..... Pikes Peak.
Altman; pass between Chaffee and Gunnison counties.
Altona; post village in Boulder County ..... Boulder.
Altruria; station in Park County on Colorado and Southern Railway.
Altura; station in Archuleta County on Denver and Rio Grande Railroad.
American Basin; valley in Hinsdale County ..... Silverton.
American Flat; valley in Hinsdale County ..... Silverton.
Americus; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,174 feet.
Ames; post village in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,678 feet..... Telluride.
Amethyst; *post* village in Mineral County on Denver and Rio *Grande Railroad*; incorporated as Creedetown.

Atlas sheet.

Amherst; station in Phillips County on Burlington and Missouri River Railroad; altitude, 3,685 feet.

Amherst; mountain in La Plata County ..... Needle Mountains.

Amity; post village in Prowers County on Atchison, Topeka, and Santa Fe Railway; altitude, 3,416 feet.

Amo; post village in El Paso County.

Anaconda; post village in Teller County on the Colorado Springs and Cripple Creek District, the Florence and Cripple Creek, and the Midland Terminal railways; population in 1900, 1,059; altitude, 9,453 feet..... Pikes Peak.

Anchor; mountain in Dolores County; altitude, 12,092 feet... Rico.

Anchoria; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Anderson; canyon in Otero County tributary to Purgatory River..... Timpas.

Anderson; creek in Montrose and San Miguel counties, a right-hand branch of San Miguel River.

Anderson; station in San Miguel County on Rio Grande Southern Railroad; altitude, 8,128 feet.

Angora; post village in Rio Blanco County.

Animas; river in La Plata County, a right-hand branch of San Juan River, flowing southward into New Mexico; discharge at Durango, July 17 to December 7, 1904, 266,900 acre-feet.

Animas; town in La Plata County on Denver and Rio Grande Railroad; population in 1900, 154; altitude, 6,540 feet..... Durango.

Animas City; mountain in La Plata County ..... Durango.

Animas Forks; post village in San Juan County.

Animas Park; valley of Animas River in the southern spurs of San Juan Mountains.

Anita; peak of Park Range, Routt County; altitude, 10,661 feet.

Anstees; station in Jefferson County on the Burlington and Missouri River and the Colorado and Southern railways.

Antelope; creek in Baca County, a right-hand branch of Horse Creek. Vilas. Albany.

Antelope; creek in Bent County, a left-hand fork of Mud Creek, tributary to Arkansas River..... Two Butte.

Antelope; creek in Custer County, a right-hand branch of Grape Creek, tributary to Arkansas River..... Canyon City.

Antelope; creek in Grand County, a left-hand branch of Muddy Creek, tributary to Grand River.

Antelope; creek in Gunnison County, a right-hand branch of Gunnison River.

Antelope; creek in Morgan County, a left-hand branch of South Platte River.

Antelope; hill in Weld County..... Greeley.

Antelope; mesa in Otero County; altitude, 4,858 feet..... Catlin.

Antelope; springs in Mineral County.

Antelope; springs in Otero County; altitude, 4,734 feet..... Catlin.

Antelope Park; open valley in Mineral and Hinsdale counties, in San Juan Mountains, on Rio Grande.

Antero, Mount; in Chaffee County; altitude, 14,245 feet.

Anthracite; creek in Gunnison county, a right-hand branch of North Fork Gunnison River ..... Anthracite.

Atlas sheet.

Anthracite; mesa in Gunnison County.

Anthracite; post village in Routt County.

Anthracite; range in Gunnison County ..... Anthracite.

Anthracite; station in Gunnison County on Denver and Rio Grande Railroad.

Antlers; post village in Garfield County on the Colorado Midland and the Denver and Rio Grande railroads; altitude, 5,350 feet.

Antonito; creek in Conejos County, a right-hand branch of Rio Conejos, tributary to Rio Grande.

Antonito; post town in Conejos County on Denver and Rio Grande Railroad; population in 1900, 347; altitude, 7,876 feet.

Anvil; mountain in San Juan County ..... Silverton.

Apache; canyon in Las Animas County, tributary to Purgatory River.

Apache; creek in Huerfano County, a left-hand branch of Huerfano River ..... Walsenburg.

Apache; post village in Huerfano County ..... Walsenburg.

Apache; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 5,934 feet ..... Walsenburg.

Apex; post village in Gilpin County.

Apishapa; bluff in Otero County; altitude, 4,675 feet ..... Catlin.

Apishapa; canyon in Las Animas County, through which flows a branch of Apishapa River..... Spanish Peaks.

Apishapa; lava dike in Las Animas County; altitude, 6,568 feet ..... Spanish Peaks.

Apishapa; post village in Las Animas County on Denver and Rio Grande Railroad; altitude, 6,146 feet..... Spanish Peaks.

Apishapa; river in Las Animas, Huerfano, and Otero counties, a right-hand branch of Arkansas River, heading in Spanish Peaks and flowing northeastward to its mouth. It originates in North and South Forks.

Arapahoe; county in the northeastern part of the State; bounded on the north by Adams County, on the east by Washington County, on the south by Douglas and Elbert counties, and on the west by Denver and Jefferson counties. The surface consists of rolling plains traversed by dry water courses, the southern tributaries of South Platte River. It is sparsely settled with the exception of the western part, where there are many stations on the great railroads, the Colorado and Southern, the Atchison, Topeka and Santa Fe, and the Denver and Rio Grande. The area is 823 square miles. This county having been reduced from 4,723 square miles to its present area, by the formation of Adams and Denver counties and the enlargement of Washington and Yuma counties, since the Census of 1900, it is impossible to give its population or the number of cultivated acres. The county seat is Littleton, a town of about 738 inhabitants in 1900. In 1900 the average magnetic declination was for the eastern part 12° 40′ east, and for the western part 13° 25′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 45° to 50°.

Atlas sheet.

Arapahoe; creek in Larimer County, a right-hand branch of Big Grizzly Creek, tributary to North Platte River.

Arapahoe; peak in Front Range on boundary between Grand and Boulder counties; altitude, 13,520 feet.

Arapahoe; station in Cheyenne County on Union Pacific Railroad; altitude, 4,012 feet ..... Cheyenne Wells.

Arastra; creek in San Juan County, a left-hand branch of Animas River ..... Silverton.

Arastra; post village in San Juan County ..... Silverton.

Arboles; post village in Archuleta County on Denver and Rio Grande Railroad; altitude 6,001 feet.

Arbourville; station in Chaffee County on Denver and Rio Grande Railroad.

Arbuckle; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Archer; station in Jefferson County on Colorado and Southern Railway ..... Denver.

Archuleta; county in the extreme southern part of the State; bounded on the north by Mineral and Hinsdale counties, on the east by Conejos County on the south by New Mexico, and on the west by La Plata County. The county is drained by the upper waters of San Juan River and its branches from the north, the chief of which are Piedra, Mariposa, Blanco, and Navajo rivers. The southern part includes the valley of San Juan River, entering which are narrow valleys from the north separated by spurs rising northward to the San Juan Mountains, in which these streams head. The greatest elevation in the county is Summit Peak, 13,323 feet. The area is 1,209 square miles, of which 10,372 acres, or 1 per cent, were under cultivation in 1900. The population in 1900 was 2,117, and of Pagosa Springs, the county seat, 367. In 1900 the average magnetic declination was 14° 20′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 40°.

Arctic; station in Jefferson County on Colorado and Southern Railway.

Arden; station in Kiowa County on Missouri Pacific Railway; altitude, 4,055 feet ..... Granada.

Arena; creek in Saguache County, a left-hand branch of San Luis Creek.

Arena; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,442 feet.

Arena; station in Cheyenne County on Union Pacific Railroad; altitude, 4,225 feet.

Arena; village in Teller County.

Arequa; gulch in Teller County, tributary to Cripple Creek..
Arequa; village in Teller County ..... } Cripple Creek Special.

Argentine; pass in Front Range, between McClellan Mountains and Grays Peak; altitude, 13,286 feet.

Argentine; post village in Summit County on Colorado and Southern Railway; altitude, 10,589 feet ..... Leadville.

Atlas sheet.

Argo; post town in Denver County, the site of extensive smelting works on the Colorado and Southern and the Burlington and Missouri River railroads; population in 1900, 443; altitude, 5,206 feet..... Denver.

Argo Junction; station in Denver County on the Colorado and Southern and the Burlington and Missouri River railroads. Denver.

Arikaree; post village in Washington County.

Arikaree; river in Arapahoe and Adams counties, a right-hand branch of Republican River.

Arkansas; river of Colorado, Kansas, Oklahoma Territory, Indian Territory, and Arkansas; one of the main western branches of Mississippi River, which it joins on the east boundary of Arkansas. The river heads in Tennessee Pass in central Colorado at an altitude of 10,000 feet above the sea; it flows first south in a mountain valley, and then east through a succession of canyons, passing out of the mountains just west of Canyon. Its course is east across the plains through eastern Colorado and Kansas, changing to southeast shortly before entering Oklahoma Territory, and so continuing through that Territory, Indian Territory, and Arkansas. Although its total length is 1,497 miles, with a drainage area of 185,671 square miles, it carries little water between Little Rock, Ark., and the western boundary of Kansas, except during times of flood, owing to the fact that the larger part of its drainage basin is within the arid region. Indeed in southern Kansas the stream bed is frequently dry in the late summer. It has many long tributaries, including White, Neosho, Verdigris, Cimarron, and Canadian rivers, but none except the White brings to it much water; the discharge for 1904 at Canyon was 409,000 acre-feet.

Arkansas; hills in Fremont County, forming the southeastern limit of South Park and extending to Arkansas River. The summits exceed 11,000 feet in height.

Arkansas; mountain in Boulder County; altitude, 7,700 feet.. Boulder.

Arkansas; mountain in Lake County; altitude, 13,807 feet.... Leadville.

Arkansas Junction; post village in Lake County on Colorado Midland Railway; altitude, 9,678 feet.

Arkansas Valley Junction; station in Lake County on Denver and Rio Grande Railroad.

Arkins; post village in Larimer County on Colorado and Southern Railway; altitude, 5,224 feet.

Arlington; post village in Kiowa County on Missouri Pacific Railway; altitude, 4,217 feet..... Las Animas.

Arloa; post village in Montezuma County.

Armel; post village in Yuma County.

Arriba; post village in Lincoln County on Chicago, Rock Island and Pacific Railway; altitude, 5,243 feet.

Arriola; village in Montezuma County.

Arrow; peak in San Juan County; altitude, 13,803 feet..... Needle Mountains.

Arrow; post village in Grand County.

Arrow Head; station in Grand County on Denver, Northwestern and Pacific Railway.

Atlas sheet.

Arroyo; station in Cheyenne County on Union Pacific Railroad; altitude, 4,563 feet ..... Arroyo.

Arthur; village in Pueblo County.

Arthurs; station in Park County on Colorado and Southern Railway; altitude, 9,172 feet.

Arvada; post village in Jefferson County on Colorado and Southern Railway; altitude, 5,330 feet ..... Denver.

Ascalon; station in Cheyenne County on Union Pacific Railroad; altitude, 4,420 feet.

Ash; village in Ouray County.

Ashcroft; post village in Pitkin County ..... Aspen.

Ashero; village in Pitkin County.

Ashland; gulch in La Plata County, tributary to La Plata River ..... La Plata.

Ashland; post village in Kit Carson County.

Aspen; creek in Gunnison County, right-hand branch of Rock Creek, tributary to Roaring Creek.

Aspen; mining city in Pitkin County on Denver and Rio Grande Railroad; population in 1900, 3,303; altitude, 7,943 feet ..... Aspen.

Aspen Junction; station in Pitkin County on the Colorado Midland and the Denver and Rio Grande railroads; altitude, 6,600 feet.

Atchee; post village in Garfield County.

Atchison; creek in Montrose County, a right-hand branch of San Miguel River.

Atchison, Topeka and Santa Fe Railway; system extending from Chicago to the Pacific coast; its main line to the west crosses the southeastern part of Colorado, following the valley of Arkansas River, which it leaves at La Junta, bearing southwest to Trinidad, south of which it crosses into New Mexico. An important branch continues up the Arkansas Valley to Pueblo, and thence through Colorado Springs to Denver.

Athol; station on Colorado and Southern Railway; altitude, 6,313 feet.

Atlanta; village in Baca County ..... Two Butte.

Atlantic; village in Gunnison County.

Atwood; post village in Logan County on the Union Pacific and the Burlington and Missouri River railroads; altitude, 3,982 feet.

Audubon; mountain in Boulder County; altitude, 13,173 feet.

Augusta; mountain in Gunnison County; altitude, 12,615 feet. Anthracite.

Ault; post village in Weld County, on Union Pacific Railroad; altitude, 4,941 feet.

Aurora; village in Adams County.

Austin; bluffs in El Paso County; altitude, 6,699 feet ..... Colorado Springs.

Austin; post village in Garfield County.

Ava; village in Pitkin County on Denver and Rio Grande Railroad.

Avalanche; creek in Pitkin County, a right-hand branch of Rock Creek, tributary to Roaring Creek.

Atlas sheet.

Avalanche; village in Pitkin County on Crystal River Railroad; altitude, 6,934 feet.

Avalo; post village in Weld County.

Avendale; village in Kit Carson County on Denver and Rio Grande Railroad.

Avery; peak in Elk Mountains, Gunnison County; altitude, 12,659 feet ..... Crested Butte.

Avoca; village in Adams County.

Avon; post village in Eagle County; altitude, 7,455 feet

Avondale; post village in Pueblo County ..... Nepesta.

Axial; post village in Routt County.

Axial Basin; extensive valley in Routt County, on Yampa River.

Axtell; mountain in Gunnison County; altitude, 12,012 feet.. Anthracite.

Ayer; station in Otero County, on Atchison, Topeka and Santa Fe Railway; altitude, 4,574 feet.

Aylmer; post village in Las Animas County. Railroad name, Bowen.

Ayr; small village in Prowers County ..... Two Butte.

Aztec; gulch in Dolores County, tributary to East Dolores River. Rico.

Aztec; mountain in La Plata County ..... Needle Mountains.

Aztec; spring in Montezuma County.

Aztec Spring; creek in Montezuma County, a right-hand branch of Rio Mancos, tributary to San Juan River.

Aztec Village; old town in Montezuma County.

Babcock; village in Chaffee County.

Babcock; peak in La Plata County ..... La Plata.

Baca; county in the southeastern part of the State; bounded on the north by Prowers and Bent counties, on the east by Kansas, on the south by Oklahoma, and on the west by Las Animas County. The surface consists of rolling plains which are covered in the southern portion by sand hills, and in the extreme south the plains are broken by many canyons tributary to the Cimarron River, which flows through the southeastern part of the State. The area is 2,531 square miles, of which 7,832 acres, or about one-half of 1 per cent, were under cultivation in 1900. The population in 1900 was 759, and of Springfield, the county seat, 44. In 1900 the average magnetic declination was 12° 25′ east. The mean annual rainfall is about 17 inches, and the mean annual temperature 50° to 55°.

Bachelor Switch; station in Ouray County on Denver and Rio Grande Railroad ..... Ouray.

Baculite; mesa in Pueblo County ..... Pueblo.

Badger; creek in Adams, Arapahoe, and Morgan counties, a left-hand branch of Beaver Creek, tributary to South Platte River.

Badger; creek in Fremont County, a left-hand tributary to Arkansas River.

Badger; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,765 feet.

Badger; station in Teller County on Colorado Springs and *Cripple Creek District* Railway.

	Atlas sheet.
Badito; peak in Huerfano County	Huerfano Park.
Badito; post village in Huerfano County	Huerfano Park.
Bagdad; station in Lincoln County on Union Pacific Railroad; altitude, 5,178 feet.	
Bailey; post village in Park County on Colorado and Southern Railway; altitude, 7,725 feet	Platte Canyon.
Baker; gulch in Grand County, tributary to North Grand River.	
Baker; peak in La Plata County	La Plata.
Baker; peak in Routt County; altitude, 9,510 feet.	
Bakers Park; valley in the heart of San Juan Mountains at the headwaters of Animas River.	
Balarat; village in Boulder County; altitude, 7,540 feet	Boulder.
Balcom; station in Jefferson County on Colorado and Southern Railway	Denver.
Bald; mountain in Front Range, Boulder County; altitude, 11,493 feet.	
Bald; mountain in Front Range, Larimer County; altitude, 11,270 feet.	
Bald; mountain in Park Range, Summit County; altitude, 13,974 feet	Leadville.
Bald; mountain in San Juan Mountains, San Miguel County; altitude, 11,700 feet	Telluride.
Bald; peak in Delta County; altitude, 10,632 feet.	
Bald Knob; summit in San Juan Mountains, La Plata County; altitude, 11,600 feet	Durango.
Bald Mountain; post village in Gilpin County	Central City Special.
Baldwin; station in Gunnison County on Colorado and Southern Railway; altitude, 8,696 feet	Anthracite.
Baldy; hill in Phillips County.	
Baldy; peak in La Plata Mountains, La Plata County	La Plata.
Baldy; peak in Ouray County; altitude, 10,615 feet	Ouray.
Baldy; station in Costilla County on Denver and Rio Grande Railroad; altitude, 7,607 feet.	
Baldy, Mount; in Elk Mountains, Gunnison County; altitude, 12,809 feet	Anthracite.
Balfour; post village in Park County.	
Ball; gulch in Boulder County, tributary to Little Jim Creek	Boulder.
Ball; mountain in Lake County	Leadville.
Ballard; mountain in San Miguel County	Telluride.
Baller; lake in Boulder County	Niwot.
Balsam; lake in San Juan County; altitude, 11,435 feet	Needle Mountains.
Baltimore; village in Gilpin County.	
Balzac; station in Morgan County, on the Union Pacific and the Burlington and Missouri River railroads; altitude, 4,095 feet.	
Balzac; village in Garfield County.	
Banded; mountain in Montezuma County	La Plata.
Banded; peak in San Juan Mountains, Archuleta County; altitude, 12,860 feet.	
Bandora; village in San Juan County	Telluride.
Banta; hill in Gilpin County; altitude, 8,750 feet	Central City Special.
Barbour Fork; in Clear Creek County, a left-hand branch of Soda Creek, tributary to Clear Creek	Georgetown.

Atlas sheet.

Bard; creek in Clear Creek County, a left-hand branch of Clear Creek ..... Georgetown.
Bardine; post village in Gunnison County.
Bare Hills; village in Fremont County ..... Pikes Peak.
Barela; post village in Las Animas County on Colorado and Southern Railway; altitude, 5,739 feet ..... Elmoro.
Barker; lake in Garfield County.
Barley; gulch in Rio Blanco County, tributary to Piceance Creek.
Barlow; creek in Dolores County, a left-hand branch of East Dolores River. Telluride. Engineer Mountain.
Barnes; station in Las Animas County, on the Denver and Rio Grande and the Colorado and Southern railways; altitude, 6,220 feet ..... Spanish Peaks.
Barnes; village in Montrose County.
Barney; lake in Boulder County ..... Niwot.
Barnroof Point; summit in La Plata County; altitude, 8,710 feet ..... Durango.
Barnum; station in Denver County, on Denver, Lakewood and Golden Railroad.
Barnum Junction; station in Arapahoe County, on Denver, Lakewood and Golden Railroad.
Barr; post village in Adams County on Burlington and Missouri River Railroad; altitude, 5,104 feet ..... Denver.
Barre; station in Chaffee County on Colorado Midland Railway; altitude, 8,579 feet.
Bartholomew; station in Summit County on Colorado and Southern Railway.
Bartlett, Mount; in Summit County ..... Leadville.
Barton; post village in Prowers County. Railroad name, Byron.
Basalt; mountain in Garfield County.
Basalt; peak in Eagle County; altitude, 11,906 feet.
Basalt; post town in Eagle County on Colorado Midland Railway; population in 1900, 382; altitude, 6,595 feet.
Basin; creek in La Plata County, a right-hand branch of La Plata River ..... La Plata.
Basin; creek in San Miguel County, a left-hand branch of San Miguel River.
Basin; plateau in San Miguel County between San Miguel and Dolores rivers.
Bass; station in La Plata County on Denver and Rio Grande Railroad.
Baster; gulch in Gunnison County, tributary to Slate River .. Crested Butte.
Bates; hill in Gilpin County ..... Central City Special.
Bates; village in Gilpin County ..... Blackhawk.
Bath; station in Chaffee County on the Colorado Midland and the Colorado and Southern railways; altitude, 9,470 feet.
Battle; mountain in Eagle County.
Battle; mountain in Teller County ..... Cripple Creek Special.
Battlement; creek in Garfield County, a left-hand branch of Grand River.

Atlas sheet.

Battlement; mesa in Garfield and Mesa counties, between Grand River and Plateau Creek; altitude, nearly 12,000 feet.

Battlement Mesa Forest Reserve; area, 1,246 square miles.

Baxter; station in Pueblo County on the Atchison, Topeka and Santa Fe and the Missouri Pacific railways; altitude, 4,624 feet.

Baxter Basin; valley in Gunnison County ..... Anthracite.

Bay City; gulch in La Plata County, tributary to La Plata River..... La Plata.

Bayfield; post village in La Plata County.

Beacon Hill; station in El Paso County on Midland Terminal Railway. Cripple Creek Special.

Beale; creek in Logan County, a left-hand branch of Horsetail Creek, tributary to South Platte River.

Beaqua; village in Teller County on Colorado Springs and Cripple Creek District Railway.

Bear; canyon in Boulder County, tributary to South Boulder Creek ..... Blackhawk.

Bear; creek in Baca County, a right-hand branch of Horse Creek. Springfield. Vilas.

Bear; creek in Clear Creek County, a left-hand branch of Turkey Creek, tributary to South Platte River..... Georgetown.

Bear; creek in El Paso County, a right-hand branch of Fountain Creek, tributary to Arkansas River..... Colorado Springs.

Bear; creek in Huerfano County, near Mosca Pass, a left-hand branch of Huerfano River ..... Huerfano Park.

Bear; creek in Jefferson and Arapahoe counties, a left-hand branch of South Platte River..... Denver.

Bear; creek in La Plata County, a left-hand branch of Animas River..... Durango.

Bear; creek in Las Animas County, a right-hand branch of Cuchara River. Walsenburg. Spanish Peaks.

Bear; creek in Montezuma County, a left-hand branch of East Dolores River ..... Rico.

Bear; creek in Ouray County, a right-hand branch of Uncompahgre River. Ouray. Silverton.

Bear; creek in Rio Grande County, a left-hand branch of Rio Grande.

Bear; creek in San Juan County, outlet of Kite Lake..... Needle Mountains.

Bear; creek in San Juan county, a right-hand branch of Animas River ..... Silverton.

Bear; creek in San Miguel County, a left-hand branch of San Miguel River..... Telluride.

Bear; gulch in Boulder county, tributary to Fourmile Creek.. Boulder.

Bear; mountain in Routt County.

Bear; mountain in San Juan Mountains, San Juan County; altitude, 12,950 feet ..... Silverton.

Bear; river in Routt and Garfield counties, a right-hand branch of Yampa River.

Bear Creek; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,849 feet. La Plata. Rico.

Bear River; mountains in San Juan Mountains in which heads Dolores River..... Needle Mountains.

	Atlas sheet.
Beartown; village in San Juan County	Needle Mountains.
Beartrack; creek in Clear Creek County, a right-hand branch of Bear Creek, tributary to South Platte River	Georgetown.
Beasley; creek in Boulder County, a left-hand branch of Boulder Creek	Niwot.
Beasley Reservoir; artificial lake in Boulder County	Niwot.
Beattie; peak in San Miguel County	Telluride.
Beaver; creek in Arapahoe, Adams, and Morgan counties, a right-hand branch of South Platte River.	
Beaver; creek in Boulder County, a left-hand branch of South St. Vrain Creek	Boulder.
Beaver; creek in Boulder County, a right-hand branch of South Boulder Creek, tributary to Boulder Creek	Blackhawk.
Beaver; creek in El Paso County, a right-hand branch of Monument Creek, tributary to Arkansas River	Castle Rock.
Beaver; creek in Fremont County, a left-hand branch of Arkansas River.	Pikes Peak. Pueblo.
Beaver; creek in Grand County, a left-hand branch of Grand River.	
Beaver; creek in Gunnison County, a left-hand branch of East River, tributary to Slate River	Crested Butte.
Beaver; creek in Larimer County, a right-hand branch of Little Thompson Creek, tributary through Thompson Creek to South Platte River.	
Beaver; creek in Larimer County, a left-hand branch of Laramie River.	
Beaver; creek in Larimer County, a right-hand branch of Raspberry Fork, tributary to North Platte River.	
Beaver; creek in Montezuma County, a right-hand branch of Dolores River.	
Beaver; creek in Park County, a left-hand branch of South Platte River	Leadville.
Beaver; creek in Rio Blanco and Routt counties, a right-hand branch of South Fork Williams River.	
Beaver; creek in Rio Grande County, a right-hand branch of Rio Grande.	
Beaver; post village in Pueblo County	Pueblo.
Beaver; ridge in Park County	Leadville.
Beaver; village in Fremont County on Denver and Rio Grande Railroad; altitude, 4,984 feet.	
Beaver Brook; creek in Clear Creek County, a left-hand branch of Little Bear Creek, tributary to Clear Creek	Georgetown.
Beaver Brook; station in Jefferson County on Colorado and Southern Railway; altitude, 6,408 feet.	
Beavercreek; village in Fremont County.	
Beaverdam; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River	Georgetown.
Beaver Station; village in Morgan County.	
Beckwith; mountain in Elk Mountains, Gunnison County; altitude, 12,371 feet.	
Beckwith; pass in Gunnison County	Anthracite.
Bedrock; creek in La Plata County, a right-hand branch of *La Plata River*	La Plata.

Atlas sheet.

Bedrock; town in Montrose County; population in 1900, 35.

Beebe Draw; stream in Weld County..... Greeley.

Beecher; post village in Yuma County.

Belden; station in Eagle County on Denver and Rio Grande Railroad.

Belford; village in Hinsdale County.

Bell; village in La Plata County.

Belle View; mountain in Rio Grande County; altitude, 12,673 feet.

Belleview; station in Chaffee County on Denver and Rio Grande Railroad.

Bellevue; mountain in Clear Creek County; altitude, 9,684 feet. Idaho Springs Special.

Bellevue; mountain in Elk Mountains, Gunnison County; altitude, 12,350 feet.

Bellevue Junction; station in Larimer County on Colorado and Southern Railway; altitude, 5,211 feet.

Bells Spur; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,578 feet.

Bellvue; post village in Larimer County; population in 1900, 99.

Bellvue; station in Teller County on Colorado Midland Railway; altitude, 8,993 feet.

Beloit; village in Kit Carson County.

Bennet; post village in Adams County on Union Pacific Railroad; altitude, 5,484 feet.

Bennetts; creek in Larimer County, a right-hand branch of South Fork Cache la Poudre River.

Bent; county in the southern part of the State; bounded on the north by Kiowa County, on the east by Prowers County, on the south by Baca and Las Animas counties, and on the west by Otero County. The surface consists chiefly of plains, and is drained by Arkansas River and its branches, the chief of which are Purgatory River, Rule Creek, and Caddoa Creek. The area is 1,497 square miles, of which 38,858 acres, or 4 per cent, were under cultivation in 1900. The population in 1900 was 3,049, and of Las Animas, the county seat, 1,192. In 1900 the average magnetic declination was 12° 15′ east. The mean annual rainfall is about 12 inches, and the mean annual temperature 50° to 55°.

Bent; creek in Hinsdale County, a left-hand branch of Lake Fork Gunnison River..... San Cristobal.

Bent Canyon; small village in Las Animas County near Purgatory River..... Timpas.

Benton; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,270 feet..... Timpas.

Bergen; mountain on boundary between Clear Creek and Jefferson counties; altitude, 9,555 feet.

Bergens Park; valley in Jefferson County; altitude, 7,543 feet.

Berkeley; lake in Denver County..... Denver.

Berkeley; town in Arapahoe County; population in 1900, 707.

Berlin; station in Arapahoe County on Colorado Eastern Railroad.

Atlas sheet.

Bernard; creek in Fremont County, a left-hand branch of Arkansas River.

Bernard; village in Mesa County.

Bernhard; creek in Teller County, a left-hand branch of Spring Creek, tributary to Arkansas River ..... Pikes Peak.

Bernice; village in Costilla County.

Berrys Ranch; station in Eagle County on Denver and Rio Grande Railroad.

Berthoud; pass in Front Range, between Clear Creek and Grand counties.

Berthoud; post village in Larimer County on Colorado and Southern Railway; population in 1900, 305; altitude, 4,962 feet.

Berwind; post village in Las Animas County on a spur of Colorado and Southern Railway; altitude, 6,462 feet..... Spanish Peaks.

Beshoar; village in Las Animas County.

Beshoar Junction; station in Las Animas County on Colorado and Southern Railway; altitude, 5,903 feet..... Elmoro.

Bessemer; post-office in Pueblo County on Colorado and Southern Railway; altitude, 4,807 feet. Railroad name, Minnequa.

Bessemer Junction; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,774 feet ..... Pueblo.

Bethesda; post village in Douglas County.

Bethune; post village in Kit Carson County on Chicago, Rock Island and Pacific Railway; altitude, 4,263 feet.

Beulah; post village and summer resort in Pueblo County.... Pueblo.

Biebles; station in Gunnison County on Colorado and Southern Railway.

Bierstadt; station in El Paso County on Colorado and Southern Railway; altitude, 6,601 feet ..... Colorado Springs.

Big; creek in Routt County, left-hand branch of Elk River, tributary to Bear River.

Big Bear; creek in San Miguel County, a left-hand branch of San Miguel River ..... Telluride.

Big Blue; creek in Gunnison County, a left-hand branch of Gunnison River.

Big Buck; creek in Gunnison County, a right-hand branch of Lake Fork Gunnison River..... Lake City.

Big Bull; mountain in Teller County..... Pikes Peak.

Big Cottonwood; creek in Fremont County, a right-hand branch of Arkansas River.

Big Dry; creek in Arapahoe and Douglas counties, a right-hand branch of South Platte River..... Denver.

Big Dry; creek in Weld County, a left-hand branch of South Platte River..... Greeley.

Big Elk Park; valley in Boulder County..... Boulder.

Big Grizzly; creek in Larimer County, a right-hand branch of North Platte River.

Bighill; station in Jefferson County on Colorado and Southern Railway ..... Blackhawk.

Bighorn; mountain in Boulder County; altitude, 8,500 feet .. Boulder.

	Atlas sheet.
Bighorn; station in Conejos County on Denver and Rio Grande Railroad; altitude, 9,022 feet.	
Bighorn; town in Larimer County.	
Big John; mountain in Boulder County; altitude, 9,077 feet..	Boulder.
Big Per Cent; gulch in La Plata County, tributary to Hermosa Creek	Durango.
Big Sand; hill in Otero County; altitude, 4,930 feet.	
Big Sandy; creek, large left-hand branch of Arkansas River.	
Big Sandy; village in Elbert County.	
Big Springs; gulch in La Plata County, tributary to Hermosa Creek	Durango.
Big Springs; town in El Paso County; altitude, 6,060 feet...	Big Springs.
Bijou; creek in Elbert, Arapahoe, and Morgan counties, a right-hand branch of South Platte River.	Castle Rock. Denver.
Bijou Basin; post village in El Paso County.	
Bilk; creek in San Miguel County, a right-hand branch of San Miguel River	Telluride.
Bilk; village in Rio Grande County on Denver and Rio Grande Railroad; altitude, 8,011 feet.	
Bilk Basin; valley in San Miguel County	Telluride.
Billy; creek in Ouray County, a right-hand branch of Uncompahgre River.	
Bingham; station in Las Animas County on Colorado and Wyoming Railway; altitude, 7,368 feet.	
Birdseye; gulch in Lake County, a left-hand branch of East Fork, Arkansas River	Leadville.
Birds Eye; station in Lake County on the Colorado and Southern and the Denver and Rio Grande railroads; altitude, 10,647 feet.	
Bishop; lakes in La Plata County	Engineer Mountain.
Bishop Rock; summit in Clear Creek County	Silver Plume Special.
Bismark; village in Saguache County; altitude, 7,736 feet.	
Bison; peak in Park County; altitude, 12,426 feet.	
Bison; station in Teller County on Colorado Midland Railway; altitude, 8,108 feet.	
Bitter; creek in Rio Blanco County, a left-hand branch of White River.	
Black; butte in Baca County; altitude, 4,074 feet	Vilas.
Black; buttes in eastern part of Las Animas County	Mesa de Maya.
Black; canyon in Delta County, tributary to North Fork Gunnison River.	
Black; canyon in Larimer County, tributary to Little Thompson Creek.	
Black; gulch in Gilpin County, tributary to South Boulder Creek	Blackhawk.
Black; hill in Park County	Leadville.
Black; hills in Las Animas County	Timpas.
Black; lake in Ouray County	Ouray.
Black; lake in Summit County.	
Black; mountain in Huerfano County; altitude, 7,412 feet.	
Black; mountain in Park County; altitude, 11,656 feet.	
Black; ridge in Pueblo County	Apishapa.

Atlas sheet.

Black Canyon of the Gunnison; extends along Gunnison River from the mouth of Lake Fork to the mouth of North Fork, with a maximum depth of 3,000 feet. The upper part is cut in sandstone, bedded horizontally or nearly so; the lower part, cut in granite, is extremely steep and rugged.

Black Face; summit in San Miguel County..... Telluride.

Blackhawk; peak in Dolores County; altitude, 12,677 feet.... Engineer Mountain.

Blackhawk; town in Gilpin County on Colorado and Southern Railway; population in 1900, 1,200; altitude, 8,045 feet.... Blackhawk.

Blackhawk; village in Dolores County.

Blackhead; peak in San Juan Mountains, Archuleta County; altitude, 12,514 feet.

Black Mountain; post village in Park County.

Black Squirrel; creek in Pueblo and El Paso counties, a left-hand branch of Chico Creek, tributary to Arkansas River. Big Springs. Nepesta.

Black Sulphur; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Black Tiger; gulch in Boulder County, a left-hand branch of Boulder Creek, tributary to St. Vrain Creek ..... Boulder.

Black Wolf; creek in Adams County, a left-hand branch of South Fork Republican River.

Blaine; post village in Baca County.

Blair; gulch in Rio Blanco County, tributary to Ryan Creek.

Blair; gulch in San Juan County, tributary to Animas River.. Silverton.

Blanca; peak in Sangre de Cristo Mountains, on boundary between Saguache, Huerfano, and Costilla counties; altitude, 14,390 feet ..... Huerfano Park.

Blanca; village in Costilla County on Denver and Rio Grande Railroad; altitude, 8,403 feet.

Bland; post village in Elbert County.

Blodgett; peak in El Paso County; altitude, 9,406 feet ..... Colorado Springs.

Bloom; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,781 feet.

Bloomerville; station in Boulder County on Colorado and Northwestern Railroad.

Blue; creek in Gunnison County, a left-hand branch of Gunnison River..... Lake City.

Blue; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Blue; hill in Las Animas County; altitude, 5,761 feet..... Apishapa.

Blue; mountain in Park County ..... Pikes Peak.

Blue; river in Middle Park, a left-hand branch of Grand River heading in Hoosier Pass and flowing northwest..... Leadville.

Blue River; peak in Summit County.

Blue River Valley; butte in Summit County; altitude, 9,400 feet.

Bluff; summit in La Plata County; altitude, 8,169 feet..... Durango

Blumer; station on Colorado and Northwestern Railroad; altitude, 8,914 feet.

Boaz; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 6,270 feet.

Bob; creek in Otero County, a left-hand branch of Arkansas *River*..... Catlin.

Atlas sheet.

Bobtail; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special.

Bobtail; hill in Gilpin County..... Central City Special.

Bocea, station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,697 feet.

Boettcher; station in Boulder County on Colorado and Southern Railway..... Niwot.

Boggs; creek in Pueblo County, a right-hand branch of Arkansas River ..... Pueblo.

Boggs Flat; bottom lands in Pueblo County ..... Pueblo.

Boiling; gulch in Gilpin County, tributary to South Boulder Creek ..... Blackhawk.

Bolton; town in Arapahoe County.

Bonanza; post village in Saguache County; population in 1900, 141.

Bonita; peak in San Juan County..... Silverton.

Bonita; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,029 feet.

Bonita; village in Saguache County.

Book Cliff; station in Mesa County on Book Cliff Railroad.

Book Cliff Railroad; small branch of Denver and Rio Grande Railroad, in Grand River Valley.

Book Cliffs; in Garfield and Rio Blanco counties, the south escarpment of Book Cliff Plateau by which one descends from its summit to Grand River Valley. The cliffs are very precipitous, especially in the upper third; altitude 8,000 to 8,500 feet.

Boomerang; gulch in Clear Creek County, tributary to Clear Creek. Idaho Springs Special.

Boone; post village in Pueblo County, on the Atchison, Topeka and Santa Fe and the Missouri Pacific railways; altitude, 4,477 feet ..... Nepesta.

Bordenville; village in Park County.

Boreas; post village in Summit County on Colorado and Southern Railway; altitude, 11,480 feet.

Boren; creek in La Plata County, a right-hand branch of La Plata River ..... La Plata.

Borst; town in El Paso County on Denver and Rio Grande Railroad; altitude, 6,582 feet.

Bosler; station in Jefferson County on Colorado and Southern Railway.

Boston; village in Baca County; altitude, 4,118 feet..... Vilas.

Boulder; creek in Boulder County, a right-hand branch of St. Vrains Creek, tributary to South Platte River. Niwot. Boulder.

Boulder; creek in Gunnison County, a right-hand branch of Gunnison River.

Boulder; county in the north-central part of the State; bounded on the north by Larimer County, on the east by Adams and Weld counties, on the south by Jefferson and Gilpin counties, and on the west by Grand County. It extends from the plains to the summit of the Front Range, and has many peaks in the western portion, the highest of which is Longs Peak, 14,271 feet. Its area is 751 square miles, of which

Atlas sheet.

Boulder—Continued.
91,708 acres, or 19 per cent, were under cultivation in 1900. This county has the highest percentage of cultivated land in the State. The population in 1900 was 21,544; of Boulder, the county seat, 6,150; and of Lyons, the town next in size, 547. In 1900 the average magnetic declination was 13° 30′ east. The mean annual rainfall is about 17 inches, and the mean annual temperature 45° to 50°.

Boulder; county seat of Boulder County, on the Colorado and Southern, the Union Pacific, and the Colorado and Northwestern railroads; population in 1900, 6,150; altitude, 5,350 feet ..... Boulder.

Boulder; gulch in Hinsdale County, tributary to Cottonwood Creek ..... San Cristobal.

Boulder; gulch in San Juan County, a right-hand branch of Animas River ..... Silverton.

Boulder; lake in Boulder County ..... Niwot.

Boulder; pass between Boulder and Grand counties; altitude, 11,670 feet.

Boulder Junction; station in Boulder County on the Colorado and Southern and the Union Pacific railroads; altitude, 5,283 feet.

Boulder; peak in San Juan Mountains; altitude, 12,417 feet.

Bovina; post village in Lincoln County on Chicago, Rock Island and Pacific Railroad; altitude, 5,372 feet.

Bovino; station in Mesa County on Rio Grand Western Railway; altitude, 4,548 feet.

Bowen; village in Las Animas County on Colorado and Southern Railway. Post-office, Aylmer.

Bowen; village in Rio Grande County.

Bowerman; post village in Gunnison County.

Bowman; village in Gunnison County.

Boxelder; creek in Adams County, a right-hand branch of South Platte River ..... Denver.

Boxelder; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Boxelder; post village in Larimer County.

Box Prairie; creek in Larimer County, a left-hand branch of Buckhorn Creek, tributary to Big Thompson Creek.

Boyds Spur; town in Weld County.

Boyer; station in Park County on Colorado Midland Railway; altitude, 8,901 feet.

Boyero; post village in Lincoln County on Union Pacific Railroad; altitude, 4,739 feet.

Bracewell; station in Weld County on Colorado and Southern Railway; altitude, 4,752 feet ..... Greeley.

Bradbury; town in Otero County on Missouri Pacific Railway.

Braddocks; station in Summit County on Colorado and Southern Railway; altitude, 9,183 feet.

Bradford; lake in Huerfano County ..... Walsenburg.

Bradford; village in Huerfano County ..... Huerfano Park.

Bragdon; ridge in La Plata County ..... La Plata.

Atlas sheet.

Bragdon; station in Pueblo County on Atchison, Topeka and Santa Fe Railway; altitude, 4,885 feet. Post-office, Eden.

Brainard; station in Boulder County on Colorado and Northwestern Railroad.

Brandon; station in Kiowa County on Missouri Pacific Railway; altitude, 3,918 feet ..... Granada.

Brayton; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,762 feet.

Brazil; post village in Las Animas County ..... Elmoro.

Breckenridge; county seat of Summit County on Colorado and Southern Railway; population in 1900, 976; altitude, 9,534 feet ..... Leadville.

Breckenridge; creek in Otero County, a left-hand branch of Horse Creek, tributary to Arkansas River..... ..... Catlin.

Breckenridge; pass between Summit and Park counties; altitude, 11,503 feet.

Breece Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,183 feet.

Breed; station in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 6,373 feet.

Breen; post village in La Plata County.

Breenes; town in Summit County.

Brendel; gulch in San Juan County, tributary to Animas River. Silverton.

Brennan; lake in Chaffee County; altitude, 10,325 feet..... Anthracite.

Brennan Spur; station on Denver and Rio Grande Railroad; altitude, 7,517 feet.

Brewster; town in Fremont County on Atchison, Topeka and Santa Fe Railway; altitude, 5,198 feet.

Bridalveil; creek in Ouray County, a right-hand branch of Uncompahgre River..... Ouray.

Bridal Veil; creek in San Miguel County, a left-hand branch of San Miguel River..... Telluride.

Bridal Veil; falls in San Miguel County..... Telluride.

Bridal Veil Basin; valley in San Miguel County..... Telluride.

Bridgeport; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,745 feet.

Briggs; town in Pitkin County on Colorado Midland Railway.

Brighton; post town and county seat of Adams County on Union Pacific Railroad; population in 1900, 366; altitude, 4,985 feet ..... Denver.

Brightside; village in Jefferson County.

Brilby; butte in Jefferson County; altitude, 9,323 feet..... Platte Canyon.

Brind; mountain in Teller County, altitude, 10,450 feet..... Cripple Creek Special.

Bristol; mountain in San Juan Mountains, Mineral County; altitude, 12,847 feet.

Bristol; plateau in Mineral County.

Bristol; village in Larimer County; altitude, 5,477 feet.

Brodhead; post village in Las Animas County, on Colorado and Southern Railway. Railroad name, Broadhead.

Brolen; village in Jefferson County.

Bronco; gulch in Costilla County, tributary to Placer Creek.. Huerfano Park.

Atlas sheet.

Brookfield; village in Baca County ..... Two Butte.
Brooklyn; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.
Brookside; post village in Fremont County on Atchison, Topeka and Santa Fe Railway; altitude, 5,240 feet.
Brookside; town in Park County on Colorado and Southern Railway; altitude, 7,916 feet.
Brookvale; post village in Clear Creek County.
Broomfield; post village in Boulder County.
Bross, Mount; in Middle Park, Grand County; altitude, 9,468 feet.
Bross, Mount; in Park Range; altitude, 14,100 feet.
Brotherton; gulch in Rio Blanco County, tributary to White River.
Brown; canyon in Las Animas County, tributary to Purgatory River..... Timpas.
Brown; gulch in Clear Creek County, tributary to Clear Creek. Georgetown.
Brown; mountain in Clear Creek County; altitude, 10,451 feet ..... Georgetown.
Brown; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,739 feet.
Browns; gulch in San Juan County, tributary to Mineral Creek ..... Silverton.
Browns Canyon; post village in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,312 feet.
Brush; creek in Chaffee County, a right-hand branch of Texas Creek, tributary to Arkansas River.
Brush; creek in Eagle County, a left-hand branch of Eagle River, originating in East and West Brush creeks.
Brush; creek in Pitkin County, a left-hand branch of Roaring Fork, tributary to Grand River..... Aspen.
Brush; post town in Morgan County, on Burlington and Missouri River Railroad; population in 1900, 381; altitude, 4,247 feet.
Brush Hollow; creek in Fremont County, a left-hand branch of Arkansas River..... Canyon City.
Bryant; post village in Phillips County.
Bryant; station in Garfield County on Colorado Midland Railway; altitude, 6,077 feet. Post-office, Satank.
Buchanan; village in Weld County on Burlington and Missouri River Railroad.
Buck; creek in Garfield County, a right-hand branch of South Fork White River.
Buck; gulch in Boulder County, tributary to North St. Vrain Creek ..... Boulder.
Buck; hollow through which flows a tributary to Animas River..... Durango.
Buckeye; gulch in Lake County, tributary to East Fork Arkansas River ..... Leadville.
Buckeye; peak in Lake County; altitude, 12,873 feet ..... Leadville.
Buckhorn; creek in Larimer County, a right-hand branch of Thompson Creek, tributary to South Platte River.
Buckhorn; *mountain in* Larimer County.

Atlas sheet.

Buckingham; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,945 feet.

Buckleys; town in Montezuma County on Denver and Rio Grande Railroad.

Buck, Mount; in Routt County; altitude, 10,877 feet.

Buckskin; creek in Park County, a right-hand branch of South Platte River ..... Leadville.

Buckskin; mountain on boundary between Lake and Park counties; altitude, 14,296 feet.

Bucktail; creek in Montrose County, a right-hand branch of San Miguel River.

Buena Vista; county seat of Chaffee County, on the Denver and Rio Grande, the Colorado and Southern, and the Colorado Midland railways; population in 1900, 1,006; altitude, 7,958 feet.

Buena Vista; peak in Routt County.

Bueno, Mount; in Boulder County; altitude, 8,700 feet ..... Boulder.

Buffalo; arroyo in the southern part of Pueblo County ..... Apishapa.

Buffalo; creek in Baca County, a left-hand branch of Horse Creek. Vilas. Albany.

Buffalo; creek in Jefferson County, a right-hand branch of North Fork South Platte River ..... Platte Canyon.

Buffalo; creek in Larimer County, a right-hand branch of North Platte River.

Buffalo; creek in Park County, a right-hand branch of South Platte River ..... Leadville.

Buffalo; creek in Prowers County, a left-hand branch of Arkansas River ..... Granada.

Buffalo; pass between Larimer and Routt counties.

Buffalo; peak in Park Range, Lake County; altitude, 13,328 feet.

Buffalo; peak in Front Range, Larimer County; altitude, 13,541 feet.

Buffalo; springs in Clear Creek County ..... Blackhawk.

Buffalo; station in Jefferson County on Colorado and Southern Railway; altitude, 6,630 feet. Post-office, Buffalo Creek .. Platte Canyon.

Buffalo Basin; sink in Lincoln County ..... Arroyo.

Buffalo Point; end of plateau in Baca County ..... Vilas.

Buffalo Springs; post village in Park County; altitude, 8,901 feet.

Buffers Spur; station in Summit County on Colorado and Southern Railway.

Buford; post village in Rio Blanco County.

Bull; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Bull; creek in Mesa County, a left-hand branch of Plateau River.

Bull Cliff; in Teller County; altitude, 10,786 feet ..... Cripple Creek Special.

Bull Hill; station in Teller County on Midland Terminal Railway.

Bullion; mountain in La Plata County ..... Needle Mountains.

Atlas sheet.

Bull Snake; hill in Lincoln County; altitude, 4,972 feet ..... Arroyo.
Bumback; springs in Fremont County ..... Pikes Peak.
Bummers; gulch in Boulder County, tributary to Boulder Creek ..... Boulder.
Bunce; village in Boulder County.
Bunker Hill; station in Huerfano County on Colorado and Southern Railway.
Burchs Lake; station in Boulder County on Burlington and Missouri River Railroad ..... Niwot.
Burdett; post village in Washington County.
Burial Rocks; cliff in El Paso County ..... Colorado Springs.
Burlington; post town and county seat of Kit Carson County on Chicago, Rock Island and Pacific Railway; population in 1900, 183; altitude, 4,163 feet.
Burlington and Missouri River Railroad; large and important system, one line of which runs from western Nebraska to Denver.
Burnett; creek in Dolores County, a right-hand branch of East Dolores River ..... Rico.
Burnham; station in Denver County on Denver and Rio Grande Railroad; altitude, 5,227 feet.
Burnina; mountain in Garfield County.
Burnito; town in Fremont County on Denver and Rio Grande Railroad; altitude, 5,359 feet.
Burns; gulch in San Juan County, tributary to Animas River. Silverton.
Burns; post village in Eagle County.
Burns; station in El Paso County on Colorado Springs and Cripple Creek District Railway.
Burns; village in Dolores County; altitude, 9,018 feet..... Rico.
Burns Junction; station in Boulder County, on the Burlington and Missouri River and the Colorado and Southern railways; altitude, 5,419 feet.
Burnt; mountain in Boulder County; altitude, 9,348 feet..... Boulder.
Burnt Timber; creek in La Plata County, a left-hand branch of La Plata River ..... La Plata.
Burro; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.
Burro; creek in Ouray County, a right-hand branch of Cow Creek, tributary to Uncompahgre River..... Ouray.
Burrows; station in Park County on Atchison, Topeka and Santa Fe Railway; altitude, 10,878 feet.
Burwell; peak in La Plata Mountains, on boundary between La Plata and Montezuma counties..... La Plata.
Busk; station in Lake County on Colorado Midland Railway; altitude, 10,788 feet..... Leadville
Butcher; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.
Butler; post village in Larimer County.
Butte; creek in Prowers County, a right-hand branch of Arkansas River..... Albany.
Butte; creek in Las Animas and Baca counties, a left-hand branch of Two Butte Creek, tributary to Arkansas River. Higbee. Two Butte.
Butte; springs in Prowers County..... Albany.

Atlas sheet.

Butter; creek, a left-hand branch of Sawatch Creek, tributary to San Luis Creek.

Butterfly; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 9,084 feet.

Buttermilk; gulch in Clear Creek County, tributary to Clear Creek — Idaho Springs Special.

Butterworth Flat; valley in El Paso County.

Buttes; post village in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 5,318 feet.

Butzel; hill in Boulder County; altitude, 8,270 feet — Boulder.

Buxton; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,784 feet.

Buzzard; creek in Mesa County, a right-hand branch of Plateau River.

Byers; post village in Arapahoe County on Union Pacific Railroad; altitude, 5,202 feet.

Byers, Mount; in Park Range, Grand County; altitude, 12,778 feet.

Byron; station in Prowers County on Atchison, Topeka and Santa Fe Railway; altitude, 3,447 feet. Post-office, Barton.

Cabeza; station in Mesa County on Colorado Midland Railway.

Cache; creek in Chaffee County, a right-hand branch of Arkansas River — Leadville.

Cache la Poudre; river in Weld County, a left-hand branch of the South Platte, heading in Front Range in two forks and flowing nearly southeast to its junction with the South Platte near Greeley — Greeley.

Cactus; valley in Garfield County, on Grand River; altitude, 5,000 feet.

Caddoa; creek in Routt County, a right-hand branch of Arkansas River — Lamar.

Caddoa; post village in Bent County on Atchison, Topeka and Santa Fe Railway; altitude, 3,765 feet — Lamar.

Calcite; post village in Fremont County.

Calf; mountain in Teller County — Cripple Creek Special.

Calhan; post village in El Paso County on Chicago, Rock Island and Pacific Railway; altitude, 6,508.

Calico; peak in Dolores County; altitude, 12,056 feet — Rico.

California; gulch in Lake County, tributary to Arkansas River — Leadville.

California; gulch in San Juan County, tributary to West Fork Cinnamon Creek — Silverton.

California; mountain in San Juan County — Silverton.

Calkins; lake in Weld County — Niwot.

Calumet; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,993 feet.

Camden; station in Morgan County on Burlington and Missouri River Railroad.

Camel; peak in Routt County; altitude, 9,158 feet.

Cameo; station in Mesa County, on the Colorado Midland and the Denver and Rio Grande railroads.

Cameron; mountain in Chaffee County.

Atlas sheet.

Cameron; post village in Teller County, on the Colorado Springs and Cripple Creek District and the Midland Terminal railways; altitude, 10,058 feet.

Cameron; station in Elbert County on Colorado and Southern Railway; altitude, 6,864 feet.

Cameron Cone; summit in Pikes Peak group, El Paso County; altitude, 10,685 feet ..... Colorado Springs.

Cameville; village in Montrose County.

Camp; creek in Routt County, a right-hand branch of Bear Creek.

Camp; creek in La Plata County, a left-hand branch of Canyon Creek, tributary to Animas River ..... Needle Mountains.

Campbell; creek in Gunnison County, a left-hand branch of Lake Fork Gunnison River ..... Lake City.

Campbell; creek in Hinsdale County, a left-hand branch of Cottonwood Creek ..... San Cristobal.

Campbell; creek in Montrose County, a right-hand branch of San Miguel River.

Campbell; peak in San Miguel County ..... Telluride.

Campbird; post village in Ouray County ..... Silverton.

Campion; station in Larimer County on Colorado and Southern Railway.

Camp Rock; summit in Clear Creek County; altitude, 8,850 feet ..... Georgetown.

Canadian; river in Larimer County, a right-hand branch of North Platte River.

Canadian; village in Larimer County.

Canby, Mount; in San Juan Mountains, San Juan County; altitude, 13,466 feet ..... Silverton.

Canfield; post village in Boulder County on Union Pacific Railroad; altitude, 5,052 feet ..... Niwot.

Cannibal; plateau in Gunnison County.

Cannon, Mount; in Boulder County; altitude, 8,500 feet ..... Boulder.

Cañon; butte in Rio Blanco County.

Cañon; creek in Garfield County, a left-hand branch of Grand River.

Cañon Park; valley in Routt County.

Canton; station in Weld County on Union Pacific Railroad.

Canyon; county seat of Fremont County, on the Denver and Rio Grande, the Atchison, Topeka and Santa Fe, and the Florence and Cripple Creek railroads; population in 1900, 3,775; altitude, 5,332 feet ..... Canyon City.

Canyon; creek in La Plata County, a left-hand branch of Animas River ..... Needle Mountains. Engineer Mountain.

Canyon; creek in Ouray County, a left-hand branch of Uncompahgre River ..... Silverton. Ouray.

Canyon Bonito; in Las Animas County, tributary to Apishapa River ..... Spanish Peaks.

Canyon de Agua; creek in Las Animas County, a right-hand branch of Apishapa River ..... Elmoro.

Capelin; village in Conejos County.

Capitol; creek in Pitkin County, a left-hand branch of Roaring *Creek, tributary to* Grand River.

Atlas sheet.

Capitol; peak in Elk Mountains, Pitkin County; altitude, 13,997 feet.

Capitol City; post village in Hinsdale County ..... Lake City.

Capps; small village in Huerfano County..... Spanish Peaks.

Cap Rock; summit in Fremont County; altitude, 9,283 feet... Pikes Peak.

Captain; mountain in Clear Creek County..... Georgetown.

Capulin; post village in Conejos County.

Carbon; creek in Gunnison County, a left-hand branch of Ohio Creek, tributary to Gunnison River. Anthracite. Crested Butte.

Carbon; Peak in Elk Mountains, Gunnison County; altitude, 12,000 feet.

Carbon; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,412 feet.

Carbonate; hill in Gunnison County..... Crested Butte.

Carbonate; hill in Lake County..... Leadville.

Carbonate; hill in Teller County ..... Cripple Creek Special.

Carbonate; lake in Garfield County.

Carbonate; village in Garfield County.

Carbondale; post town in Garfield County, on the Denver and Rio Grande, the Crystal River, and the Colorado Midland railroads; population in 1900, 173; altitude, 6,171 feet.

Carbon, Mount; in Elk Mountains, Gunnison County; altitude, 12,000 feet..... Anthracite.

Cardiff; post village in Garfield County on Colorado Midland Railway; altitude, 5,921 feet.

Caribou; post village in Boulder County; altitude, 9,905 feet.

Cardinal; village in Boulder County.

Carlile; spring in Pueblo County..... Pueblo.

Carlile; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,940 feet.

Carlin; gulch in Fremont County, tributary to Oil Creek..... Pikes Peak.

Carlisle; station in Kit Carson County, on Chicago, Rock Island and Pacific Railway.

Carlton; post village in Prowers County on Atchison, Topeka and Santa Fe Railway; altitude, 3,527 feet. Railroad name, Grote ..... Granada.

Carlton; station in El Paso County on Denver and Rio Grande Railroad; altitude, 6,245 feet.

Carnero; creek in Saguache County, flowing into a sink.

Carnero; post village in Saguache County.

Carpenter; spring in Pueblo County ..... Nepesta.

Carpenter; station in Mesa County, on Denver and Rio Grande Railroad.

Carr; post village in Weld County on Union Pacific Railroad; altitude, 5,691 feet.

Carr; station in Costilla County on Denver and Rio Grande Railroad.

Carr; station in Morgan County on Burlington and Missouri River Railroad.

Carr; station on Colorado and Southern Railway; altitude, 5,706 feet.

Carracas; station in Archuleta County on Denver and Rio Grande Railroad; *altitude, 6,161 feet.*

Atlas sheet.

Carrizo; creek in Baca County, a left-hand branch of Cimarron River..... Springfield.
Carroll; creek in Fremont County, a left-hand branch of Arkansas River.
Carson; creek in La Plata County, tributary to Animas River.. Durango.
Carson; village in Hinsdale County; altitude, 12,360 feet..... San Cristobal.
Carter; station in Pueblo County on Atchison, Topeka and Santa Fe Railway; altitude, 4,797 feet.
Carter; valley in Montrose County.
Cascade; creek in Clear Creek County, a left-hand branch of West Chicago Creek, tributary to Clear Creek..... Georgetown.
Cascade; creek in Gunnison County, a left-hand branch of East River, tributary to Gunnison River..... Crested Butte.
Cascade; creek in San Juan County, a right-hand branch of Animas River..... Engineer Mountain.
Cascade; gulch in San Juan County, tributary to Cement Creek..... Silverton.
Cascade; mountain in Elk Mountains, Gunnison County; altitude, 11,707 feet..... Anthracite.
Cascade; mountain in Ouray County..... Ouray.
Cascade; post village in El Paso County on Colorado Midland Railway. Railroad name, Cascade Canyon..... Colorado Springs.
Cascade; station in Chaffee County on Colorado and Southern Railway; altitude, 9,017 feet.
Cascade; station in La Plata County on Denver and Rio Grande Railroad; altitude, 7,773 feet..... Engineer Mountain.
Cascade Canyon; station in El Paso County on Colorado Midland Railway; altitude, 7,406 feet. Post-office, Cascade.
Case; post village in Douglas County.
Cashin; village in Montrose County.
Cassells; post village in Park County on Colorado and Southern Railway.
Castilar; post village in La Plata County.
Castilleia; lake in La Plata County..... Needle Mountains.
Castle; creek in Gunnison County, a right-hand branch of Ohio Creek, tributary to Gunnison River..... Anthracite.
Castle; creek in La Plata County, a left-hand branch of Junction Creek, tributary to Animas River..... Durango.
Castle; creek in Pitkin County, a left-hand branch of Roaring Fork, tributary to Grand River..... Aspen.
Castle; gulch in Boulder County, tributary to Jim Creek..... Boulder.
Castle; peak in Elk Mountains, Pitkin County; altitude, 14,259 feet..... Aspen.
Castle; summit in Park County; altitude, 9,863 feet..... Platte Canyon.
Castle Rock; county seat of Douglas County, on the Denver and Rio Grande and the Atchison, Topeka and Santa Fe railways; population in 1900, 304..... Castle Rock.
Castle Rock; spring in La Plata County..... Engineer Mountain.
Castle Rock; summit in Boulder County; altitude, 7,777 feet. Blackhawk.
Castle Rock; summit in Douglas County; altitude, 6,590 feet. Castle Rock.
Castle Rock; summit in Gilpin County..... Central City Special.
Castles; station in Eagle County, on Colorado Midland Railway; *altitude, 6,954* feet.

Atlas sheet.

Castleton; station in Gunnison County on Colorado Southern Railway; altitude, 8,387 feet.

Castleview; station in Lake County on Denver and Rio Grande Railroad.

Casto; creek, a left-hand branch of South Platte River.

Cat; creek in Baca County, right-hand branch of Bear Creek, tributary to Horse Creek ..... Springfield.

Catamount; creek in Teller and El Paso counties, a right-hand branch of Fountain Creek, tributary to Arkansas River ... Pikes Peak.

Cataract; creek in San Juan County, a left-hand branch of South Fork Mineral Creek ..... Telluride.

Cataract; gulch in Hinsdale County, tributary to Cottonwood Creek ..... San Cristobal.

Cataract; gulch in San Juan County, tributary to Animas River..... Silverton.

Cathedral; bluffs in Rio Blanco County.

Cathedral; creek in Rio Blanco County, a right-hand branch of Douglas Creek.

Cathedral; mountain in Elk Mountains, Gunnison County; altitude, 11,169 feet.

Cathedral; post village in Hinsdale County.

Catherine; station in Garfield County on Colorado Midland Railway; altitude, 6,291 feet.

Catlin; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,265 feet ..... Catlin.

Cattle; creek in Eagle and Garfield counties, a right-hand branch of Roaring Fork Grand River.

Cattle Creek; station in Garfield County on Denver and Rio Grande Railroad; altitude, 6,027 feet.

Cave; creek in Boulder County, a left-hand branch of Middle St. Vrain Creek, tributary to St. Vrain Creek ..... Boulder.

Caylor; gulch in Jefferson County, a left-hand branch of South Platte River..... Pikes Peak.

Cebolla; creek in Gunnison County, a left-hand branch of White Earth Creek, tributary to Lake Fork Gunnison River.

Cebolla; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,344 feet.

Cedar; creek in Logan County, a left-hand branch of Horsetail Creek, tributary to South Platte River.

Cedar; creek in Montrose County, a right-hand branch of Uncompahgre River.

Cedar; mountain in Routt County; altitude, 7,668 feet.

Cedar; post village in San Miguel County.

Cedar Creek; post village in Montrose County on Denver and Rio Grande Railroad; altitude, 6,742 feet.

Cedar Edge; post village in Delta County.

Cedarhurst; post village in Las Animas County.

Cedar Point; station in Elbert County on Union Pacific Railroad; altitude, 5,711 feet.

Cedar Point; peak of plateau in Elbert County; altitude, 6,003 feet..... Limon.

Atlas sheet.

Cement; creek in Gunnison County, a left-hand branch of East River, tributary to Gunnison River..... Crested Butte.

Cement; creek in San Juan County, a right-hand branch of Animas River, originating in North, South, and Middle forks ..... Silverton.

Cement; mountain in Elk Mountains, Gunnison County; altitude, 12,212 feet..... Crested Butte.

Cement; station in Fremont County on Denver and Rio Grande Railroad.

Cemetery Park; valley in Fremont County ..... Pikes Peak.

Cenicero; town in Conejos County.

Center; post village in Saguache County.

Centerview; village in Saguache County.

Centerville; post village in Chaffee County; altitude, 7,727 feet.

Central; gulch in Boulder County, a right-hand branch of south St. Vrain Creek ..... Boulder.

Central; hill in Gilpin County..... Central City Special.

Central City; county seat of Gilpin County on Colorado and Southern Railway; population in 1900, 3,114; altitude, 8,516 feet..... Central City Special.

Cerro del Navajo; mesa rising from Rio Navajo on boundary between Colorado and New Mexico; altitude, 9,161 feet.

Cerro Summit; station in Montrose County on Denver and Rio Grande Railroad; altitude, 7,958 feet.

Chacra; station in Garfield County on Denver and Rio Grande Railroad; altitude, 5,640 feet.

Chaffee; county in the central part of the State; bounded on the North by Lake County, on the east by Park and Fremont counties, on the south by Saguache County, and on the west by Gunnison County. It extends from the summit of Park Range to the summit of Sawatch Range on the west, including the broad valley of Arkansas River. Its area is 1,224 square miles, of which 2 per cent, or 14.726 acres, were under cultivation in 1900. The population in 1900 was 7,085; of Buena Vista, the county seat, 1,006, and of Salida, the largest city, 3,722. In 1900 the average magnetic declination was 14° 00′ east. The mean annual rainfall is about 12 inches, and the mean annual temperature 40° to 50°.

Chair; mountains in Gunnison County.

Chalcedony; buttes in southern part of South Park; altitude, 10,200 feet.

Chalk; creek, a right-hand branch of Arkansas River.

Chalk; mountain on boundary between Summit and Eagle counties ..... Leadville.

Chama; peak in San Juan Mountains; altitude, 12,248 feet.

Chama; village in Costilla County.

Chambers; village in Larimer County; altitude, 9,106 feet.

Champion; mountain in Pitkin County.

Champion; station in Huerfano County on Denver and Rio Grande Railroad.

Champion Basin; valley in Ouray County ..... Silverton.

Chance; village in Gunnison County.

Atlas sheet.

Chandler; creek in Fremont County, a right-hand branch of Arkansas River ..... Canyon City.

Chandler; post village in Fremont County on Denver and Rio Grande Railroad.

Chandler Junction; station in Fremont County on Denver and Rio Grande Railroad; altitude, 5,202 feet.

Chaney; lake in Gunnison County.

Chapin; village in Kit Carson County.

Chapman; gulch in San Miguel County, tributary to Howard Fork, branch of Lake Fork San Miguel River ..... Telluride.

Chapman; station in Boulder County on Burlington and Missouri Riyer Railroad; altitude, 5,175 feet ..... Niwot.

Chapman, Mount; in Gunnison County.

Chaquaqua; canyon in Las Animas County, drained by Chaquaqua Creek, tributary to Purgatory River ..... Mesa de Maya.

Chaquaqua; creek in Las Animas County, a right-hand branch of Purgatory River. Mesa de Maya. Timpas.

Charcoal; station in Chaffee County on Denver and Rio Grande Railroad.

Charles; station in Mesa County on Denver and Rio Grande Railroad.

Chase; gulch in Gilpin County, tributary to North Clear Creek .. Central City Special.

Chase; post village in Park County on Colorado and Southern Railway.

Chatfield; station in Jefferson County on Colorado and Southern Railway.

Chatillion; creek in Saguache County, a left-hand branch of San Luis Creek.

Chattanooga; station in San Juan County on Silverton Railroad ..... Silverton.

Chautauqua; village in Boulder County; altitude, 5,718 feet .. Blackhawk.

Cheesman; town in Jefferson County.

Chelsea; station in Logan County on Burlington and Missouri River Railroad.

Chemung; station in Cheyenne County on Union Pacific Railroad; altitude, 3,928 feet.

Chenoweth; village in Elbert County.

Cherokee; gulch in Clear Creek County, tributary to Clear Creek ..... Georgetown.

Cherrelyn; post village in Arapahoe County.

Cherry; creek in Denver County; a right-hand branch of South Platte River, joining the latter in the city of Denver. Castle Rock. East Denver.

Cherry; creek in La Plata County, a right-hand branch of La Plata River ..... La Plata.

Cherry; creek in Routt County, a left-hand branch of Yampa River.

Cherry; post village in Douglas County.

Cherrydale; village in La Plata County.

Chester; station in Saguache County on Denver and Rio Grande Railroad; altitude, 9,402 feet.

Cheyenne; county in the eastern part of the State; bounded on the north by Kit Carson County, on the east by Kansas,

Atlas sheet.

Cheyenne—Continued.
on the south by Kiowa County, and on the west by Lincoln County. Its surface consists of high rolling plains. Its area is 1,787 square miles, of which less than one-half of 1 per cent, or 2,740 acres, were under cultivation in 1900. The population in 1900 was 501, and of Cheyenne Wells, the county seat, 179. In 1900 the average magnetic declination was 12° 25′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Cheyenne; creek in El Paso County, a right-hand branch of Fountain Creek, tributary to Arkansas River..... Colorado Springs.

Cheyenne; creek in Prowers County, a right-hand branch of Arkansas River ..... Granada.

Cheyenne; creek in Grand County, a left-hand branch of West Fork North Platte River.

Cheyenne; mountain in El Paso County; altitude, 9,407 feet. Colorado Springs.

Cheyenne Wells; county seat of Cheyenne County on Union Pacific Railroad; altitude, 4,279 feet..... Cheyenne Wells.

Chicago; creek in Clear Creek County, a right-hand branch of Clear Creek..... Georgetown.

Chicago; gulch in La Plata County, a right-hand branch of Junction Creek..... Durango.

Chicago; lake in Clear Creek County; altitude, 11,500 feet... Georgetown.

Chicago; mountain in Eagle County..... Tenmile District Special.

Chicago; ridge of mountains in Eagle County..... Tenmile District Special.

Chicago Basin; valley in La Plata County..... Needle Mountains.

Chicago, Rock Island and Pacific Railway; an extensive system occupying territory in the Central States. It has one line in Colorado running from the east to Colorado Springs.

Chicito Hill; summit in Conejos County; altitude, 9,773 feet.

Chicken; creek in Las Animas County, a right-hand branch of Purgatory River..... Spanish Peaks.

Chicken; creek in Montezuma County, a right-hand branch of Dolores River..... La Plata.

Chico; creek in Pueblo County, a left-hand branch of Arkansas River..... Nepesta.

Chico; station in Pueblo County on Atchison, Topeka and Santa Fe Railway; altitude, 4,549 feet..... Nepesta.

Chicorica; creek in Las Animas County, a right-hand branch of San Francisco Creek, tributary to Purgatory River..... Elmoro.

Chicorico; mesa in Las Animas County, near Mesa de Maya.. Mesa de Maya.

Chicosa; canyon in Las Animas County, through which flows Chicosa Creek, tributary to Purgatory River..... Spanish Peaks.

Chicosa; post village in Las Animas County on Denver and Rio Grande Railroad..... Spanish Peaks.

Chicosa Junction; station in Las Animas County on the Colorado and Southern and the Denver and Rio Grande railroads; altitude, 6,104 feet.

Chief; creek in Yuma County, a left-hand branch of Republican *River.*

Atlas sheet.

Chief; mountain in Clear Creek County; altitude, 11,710 feet.. Georgetown.
Chihuahua; village in Summit County.
Chimney; creek in Larimer County, a right-hand branch of Yampa River.
Chimney; creek in Routt County, a right-hand branch of Bear River, tributary to Yampa River.
Chimney; gulch in Jefferson County, tributary to Clear Creek.
Chimney; peak on boundary between Hinsdale and Ouray counties; altitude, 11,785 feet..... Ouray.
Chimney Gulch; town in Jefferson County on Colorado and Southern Railway; altitude, 5,926 feet.
Chipeta; station in Delta County on Denver and Rio Grande Railroad; altitude, 5,161 feet.
Chipeta; village in Pitkin County.
Chipmunk; gulch in Boulder County, tributary to Jim Creek. Boulder.
Chiquita; peak in Conejos County; altitude, 9,627 feet.
Chivington; post village in Kiowa County on Missouri Pacific Railroad; altitude, 3,887 feet..... Lamar.
Christian; canyon in Las Animas and Pueblo counties, tributary to Apishapa River ..... Apishapa.
Chromo; post village in Archuleta County on Rio Grande and Pagosa Springs Railroad.
Chrysolite Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 10,242 feet.
Churches; station in Jefferson County, on the Colorado and Southern, and the Burlington and Missouri River railroads. Denver.
Cima; station in La Plata County on Denver and Rio Grande Railroad; altitude, 8,588 feet..... La Plata.
Cima; station in Las Animas County on Atchison, Topeka and Santa Fe Railway.
Cimarron; creek in Gunnison County, a left-hand branch of Gunnison River. Lake City. Ouray.
Cimarron; post village in Montrose County on Denver and Rio Grande Railroad; altitude, 6,896 feet.
Cimarron; ridge forming the boundary between Gunnison and Ouray counties..... Ouray.
Cimarron; river in Colorado, New Mexico, Oklahoma, and Indian Territory, a right-hand branch of Arkansas River. It rises in the high plains in two forks in southeastern Colorado and northwestern New Mexico, and flows with a general easterly course to near Keystone, Okla.; discharge at Cimarron from March 24 to November 10, 1904, 79,020 acre-feet.
Cinder; buttes in La Plata County; altitude, 6,614 feet.
Cinnamon; creek in San Juan County, a left-hand branch of Animas River..... Silverton.
Cinnamon; mountain in Gunnison County; altitude, 12,278 feet ..... Anthracite.
Cinnamon; pass between Hinsdale and San Juan counties.... Silverton.
Citadel; plateau in Routt County.
Claremont; post village in Kit Carson County on Chicago, Rock Island and Pacific Railway; altitude, 4,407 feet. Railroad name, Machias.

Atlas sheet.

Clark; post village in Routt County.

Clarks; lake in Garfield County.

Clarks; peak in Front Range, Larimer County; altitude, 13,167 feet.

Clarkson; village in Grand County.

Clarkston; village in Boulder County.

Clay; creek in Montrose County, a right-hand branch of San Miguel River, tributary to Dolores River.

Clay; creek in Powers County, a right-hand branch of Arkansas River. — Two Butte. Lamar.

Clay Creek; spring in southeastern part of Bent County..... Two Butte.

Clayer; village in Mesa County.

Clayton Cone; summit in Saguache County; altitude, 9,500 feet.

Claytonia; village in Saguache County; altitude, 8,386 feet.

Clear; creek, a right-hand branch of South Arkansas, tributary to Arkansas River.

Clear; creek in Chaffee County, a right-hand branch of Arkansas River..... Leadville.

Clear; creek in Jefferson, Denver, and Adams counties, a left-hand branch of South Platte River; discharge at Forks Creek, April 1 to October 31, 1904, 196,600 acre-feet..... Blackhawk.

Clear; creek in Logan County, a left-hand branch of South Platte River.

Clear; lake in Clear Creek County; altitude, 9,870 feet..... Georgetown.

Clear; lake in San Juan County..... Telluride.

Clear Creek; county in the central part of the State; bounded on the north by Grand and Gilpin counties, on the east by Jefferson County, on the south by Park County, and on the west by Summit County. Its surface is mountainous, consisting of sloping spurs, with narrow valleys between them running down from Front Range, which forms its western boundary. Its area is 425 square miles, of which less than one-half of 1 per cent, or 1,196 acres, were under cultivation in 1900. The population in 1900 was 7,082; and of Georgetown, the county seat, 1,418. In 1900 the average magnetic declination was 13° 30′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 40° to 45°.

Clear Water; creek in Mesa County, a left-hand branch of Plateau Creek, tributary to Grand River.

Clelland; station in Fremont County, on Atchison, Topeka and Santa Fe Railway; altitude, 5,166 feet.

Clelland Junction; station on Atchison, Topeka and Santa Fe Railway; altitude, 5,176 feet.

Cleora; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 6,971 feet.

Cleveland; gulch in Hinsdale County, tributary to Gunnison River..... Silverton.

Cliff; creek in Gunnison County, a right-hand branch of Coal Creek, tributary to North Fork Gunnison River..... Anthracite.

Cliff; post village in Jefferson County on Colorado and Southern Railway.

Atlas sheet.

Clifton; post village in Mesa County, on the Colorado Midland and the Denver and Rio Grande railroads; altitude, 4,703 feet.

Climax; station in Lake County on Colorado and Southern Railway; altitude, 11,302 feet.

Clinton; gulch in Summit County, tributary to Tenmile Creek. Leadville.

Clommel; village in Fremont County.

Clover; village in Mesa County.

Club; creek in Rio Blanco County, a left-hand branch of White River.

Clyde; post village in Teller County on Colorado Springs and Cripple Creek District Railway; altitude, 9,427 feet.

Coal; creek in Arapahoe County, a right-hand branch of Sand Creek, tributary to South Platte River ..... Denver.

Coal; creek in Boulder and Weld counties, a right-hand branch of Boulder Creek, tributary to St. Vrain Creek..... Niwot.

Coal; creek in Fremont County, a right-hand branch of Arkansas River..... Canyon City.

Coal; creek in Gunnison County, a right-hand branch of Slate River..... Anthracite.

Coal; creek in Ouray County, a left-hand branch of Uncompahgre River..... Ouray.

Coal; creek in Rio Blanco County, a right-hand branch of White River.

Coal; creek in San Juan County, a left-hand branch of Rio Grande..... Silverton.

Coal; mountain in Routt County; altitude, 8,430 feet.

Coalbank; hill in San Juan County; altitude, 10,854 feet..... Engineer Mountain.

Coalbasin; post village in Pitkin County on Crystal River Railroad; altitude, 9,432 feet.

Coal Branch Junction; station in Park County on Colorado and Southern Railway.

Coal Creek; peak in Jefferson County ..... Denver.

Coal Creek; village in Jefferson County on Denver, Northwestern and Pacific Railway ..... Blackhawk.

Coal Creek Junction; station in Fremont County on Denver and Rio Grande Railroad; population in 1900, 698; altitude, 5,187 feet ..... Canyon City.

Coaldale; post village in Fremont County on Denver and Rio Grande Railroad. Railroad name, Pleasanton.

Coal Park; station in Boulder County on Burlington and Missouri River Railroad..... Denver.

Coalridge; station in Garfield County on Colorado Midland Railway; altitude, 5,628 feet.

Cobbs; gulch in Ouray County, tributary to Cow Creek..... Ouray.

Coburn; station on Denver and Rio Grande Railroad; altitude, 5,568 feet.

Cochem; village in Chaffee County.

Cochetopa; creek in Saguache County, a right-hand branch of Tomichi Creek, tributary to Gunnison River.

Cochetopa; hills extending southwest of the southeastern end of Sawatch Range, joining it with San Juan Mountains, forming the northwestern limit of San Luis Valley. The summits reach 12,000 feet in altitude.

Atlas sheet.

Cochetopa; pass over the main divide from San Luis Valley to the Gunnison; altitude, 10,032 feet.

Cochetopa; post village in Saguache County; altitude, 9,088 feet.

Cochetopa Dome; summit in Saguache County; altitude, 10,000 feet.

Cochetopa Forest Reserve; area, 1,770 square miles.

Cockrell; village in Conejos County.

Cody; station in Washington County on Burlington and Missouri River Railroad.

Coffee Pot; gulch in Garfield County, tributary to Eagle River.

Coffin; lake in Boulder County ..... Niwot.

Coffintop; gulch in Boulder County, tributary to South St. Vrain Creek ..... Boulder.

Coffintop; mountain in Boulder County; altitude, 8,050 feet .. Boulder.

Coke Oven; creek in Dolores County, a right-hand branch of East Dolores River ..... Telluride.

Coke Ovens; station in Dolores County on Denver and Rio Grade Railroad; altitude, 9,197 feet.

Coke Ovens; station in Las Animas County on Denver and Rio Grande Railroad.

Collbran; village in Mesa County.

Collier; creek in Mesa County, a right-hand branch of Plateau River.

Collina; station in La Plata County on Denver and Rio Grande Railroad.

Collins; station in Las Animas County on Colorado and Southern Railway.

Colona; post village in Ouray County on Denver and Rio Grande Railroad; altitude, 6,399 feet.

Colony; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Colorado; canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.

Colorado and Northwestern Railroad; line running from Boulder to Ward, a distance of 26 miles.

Colorado and Southeastern Railway; line extending from Delagua to Ludlow and thence to Trinidad, a distance of 28 miles.

Colorado and Southern Railway; system made up of numerous short lines, mostly in Colorado. One line connects Denver with Leadville; another runs from Denver to Pueblo, thence over the Denver and Rio Grande Railroad tracks to Trinidad, and thence to Fort Worth, Tex. Other short lines lead out of Denver and Pueblo.

Colorado and Wyoming Railway; line connecting Trinidad with Tercio, near the southern boundary of the State.

Colorado City; in El Paso County, on the Colorado Midland and the Denver and Rio Grande railroads; population in 1900, 2,914; altitude, 6,077 feet ..... Colorado Springs.

Colorado City Junction; station in El Paso County on Colorado Springs and Cripple Creek District Railway.

Atlas sheet.

Colorado Eastern Railroad; line running from Denver to Scranton, a distance of 17 miles.

Colorado Midland Railway; line connecting Colorado Springs and Glenwood Springs, thence continuing over the Denver and Rio Grande tracks to Grand Junction.

Colorado Springs; county seat of El Paso County; a health resort, and an important railroad center entered by six different lines; population in 1900, 21,085; altitude, 5,878 feet ..... Colorado Springs.

Colorado Springs and Cripple Creek District Railway; line connecting Colorado Springs and Cripple Creek, passing through the gold district.

Colorow; village in Grand County.

Colton; town in San Miguel County.

Columbia; gulch in Chaffee County, tributary to Arkansas River ..... Leadville.

Columbia; mountain in Clear Creek County ..... Georgetown.

Columbine; lake in La Plata County; altitude, 8,788 feet ..... Engineer Mountain. Needle Mountains.

Columbine; pass in La Plata County ..... Needle Mountains.

Columbine; post village in Routt County.

Columbine; town in Teller County, on the Colorado Springs and Cripple Creek District and the Florence and Cripple Creek railways.

Columbus; station in Chaffee County on Denver and Rio Grande Railroad.

Columbus; village in La Plata County; altitude, 7,321 feet.

Comanche; creek in Elbert, Arapahoe, and Adams counties, a right-hand branch of Kiowa Creek, tributary to South Platte River.

Commodore; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Como; lake in San Juan County ..... Silverton.

Como; post town in Park County on Colorado and Southern Railway; altitude, 9,785 feet.

Condon; village in Adams County.

Conejos; county in the southern part of the State; bounded on the north by Rio Grande and Costilla counties, on the east by Costilla County, on the South by New Mexico, and on the west by Archuleta County. It includes part of San Luis Valley which extends on the west into San Juan Mountains. Its area is 1,407 square miles, of which 10 per cent, or 98,960 acres, were under cultivation in 1900. The population in 1900 was 8,794; and of Conejos, the county seat, 348. In 1900 the average magnetic declination was 12° 50′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 40°.

Conejos; county seat of Conejos County on Denver and Rio Grande Railroad; population in 1900, 348; altitude, 7,880 feet.

Conejos; ferry across Rio Grande between Conejos and Costilla counties.

Atlas sheet.

Conejos; mountain in Conejos County; altitude, 13,183 feet.
Conical or Upper Muddy; butte in Larimer County; altitude, 9,848 feet.
Conifer; post village in Jefferson County; altitude, 8,153 feet.
Conrad; post village in Park County.
Conroy; canyon in Las Animas County, tributary to Purgatory River ..... Timpas.
Content; post village in La Plata County.
Conundrum; creek in Pitkin County, a left-hand branch of Castle Creek, tributary to Roaring Fork ..... Aspen.
Cooke; creek in Mineral County, a right-hand branch of Hot Springs Creek, tributary to Rio Grande.
Cook, Mount; in Boulder County; altitude, 7,500 feet..... Boulder.
Cooley; creek in Fremont County, a left-hand branch of Big Cottonwood Creek, tributary to Arkansas River.
Coon; creek in La Plata County, a left-hand branch of Animas River ..... Durango.
Coon; gulch in Jefferson County, tributary to Clear Creek.... Denver.
Coon; valley in Kiowa County ..... Granada.
Coon Basin; valley in Gunnison County ..... Anthracite.
Cooper; creek in Hinsdale County, a left-hand branch of Cottonwood Creek ..... San Cristobal.
Cooper; town in Morgan County on Union Pacific Railroad.
Cooper, Mount; in Fremont County ..... Pikes Peak.
Cope; post village in Washington County.
Copper; creek in Gunnison County, a left-hand branch of East River ..... Crested Butte.
Copper; creek in Summit County, a left-hand branch of Tenmile Creek, tributary to Snake River ..... Leadville.
Copper; gulch in Fremont County, tributary to Arkansas River ..... Canyon City.
Copper; gulch in Hinsdale County, tributary to Henson Creek. Lake City.
Copper; gulch in San Juan County, tributary to South Fork Animas River ..... Silverton.
Copper; hill in Lake County ..... Leadville.
Copper; mountain in Summit County; altitude, 12,475 feet.... Leadville.
Copper; village in Mesa County.
Copperdale; village in Jefferson County; altitude, 7,624 feet.. Blackhawk.
Copperkettle; creek in Adams County, a left-hand branch of South Fork Republican River.
Copper Rock; station in Boulder County on Colorado and Northwestern Railroad; altitude, 7,369 feet.
Copper Rock; summit in Boulder County; altitude, 7,419 feet. Boulder.
Coral; gulch in Rio Blanco County, tributary to White River.
Coral; station in Fremont County on Denver and Rio Grande Railroad.
Corbett; creek in Ouray County, a left-hand branch of Uncompahgre River ..... Ouray.
Corbett; hill on boundary between Summit and Eagle counties. Tenmile District Special.
Corcoran; village in Arapahoe County.
Corkscrew; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Atlas sheet.

Cornet; creek in San Miguel County, a right-hand branch of San Miguel River..... Telluride.

Cornet; falls in San Miguel County..... Telluride.

Cornwall; village in Rio Grande County; altitude, 9,145 feet.

Corona; station in Morgan County on Burlington and Missouri River Railroad; altitude, 4,559 feet. Post-office, Wiggins.

Coronado; station in Denver County on Colorado and Southern Railway; altitude, 6,008 feet.

Corral; bluffs in El Paso County; altitude, 6,794 feet..... Colorado Springs.

Corral; creek in Clear Creek County, a left-hand branch of Bear Creek, tributary to South Platte River.

Corral; peak in Grand County; altitude, 11,333 feet.

Corrizo; post village in Baca County.

Cortez; post village and county seat of Montezuma County; population in 1900, 125.

Cortrite; village in Park County.

Cory; post village in Delta County on Denver and Rio Grande Railroad; altitude, 5,060 feet.

Costilla; county in the southern part of the State; bounded on the north by Saguache and Huerfano counties, on the east by Huerfano and Las Animas counties, on the south by New Mexico, and on the west by Conejos and Rio Grande counties; it includes a part of San Luis Valley, while the east boundary is the summit of Sangre de Cristo Range. The area is 1,746 square miles, of which 7 per cent, or 79,678 acres, were under cultivation in 1900. The population in 1900 was 4,632; and of San Luis, the county seat, 350. In 1900 the average magnetic declination was 12° 45′ east. The mean annual rainfall is about 13 inches, and the mean annual temperature 40° to 45°.

Costilla; creek in Costilla County, a left-hand branch of Rio Grande.

Cotopaxi; post village in Fremont County on Denver and Rio Grande Railroad; altitude, 6,373 feet.

Cotton; creek in Saguache County, a left-hand branch of San Luis Creek.

Cottonwood; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.

Cottonwood; creek in Costilla County, a left-hand branch of Rio Grande..... Huerfano Park.

Cottonwood; creek in Fremont County, a right-hand branch of Currant Creek, tributary to Arkansas River..... Pikes Peak.

Cottonwood; creek in Hinsdale County, a left-hand branch of Lake Fork of Gunnison River..... San Cristoba.

Cottonwood; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Cottonwood; creek in Las Animas County, a left-hand branch of Carrizo Creek, tributary to Cimarron River..... Mount Carrizo.

Cottonwood; creek in Mesa County, a left-hand branch of Plateau River.

Atlas sheet.

Cottonwood; creek in Montrose County, a left-hand branch of Gunnison River.

Cottonwood; creek in Prowers County, a left-hand branch of Arkansas River ..... Granada.

Cottonwood; creek in Saguache County, a left-hand branch of San Luis Creek.

Cottonwood; gulch in Dolores County, tributary to West Fork Dolores River.

Cottonwood; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Cottonwood; spring in Chaffee County.

Cottonwood; spring in Pueblo County ..... Apishapa.

Cottonwood; station in Gilpin County on Colorado and Southern Railway; altitude, 7,190 feet..... Blackhawk.

Cottonwood; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,397 feet. Post-office, Liberty.

Cottonwood; village in Gunnison County; altitude, 11,900 feet.

Coulter; post village in Grand County; altitude, 9,255 feet.

Courthouse; mountain on boundary between Hinsdale and Ouray counties; altitude, 12,165 feet..... Ouray.

Coventry; post village in Montrose County.

Cover; mountain in Park County; altitude, 10,165 feet..... Pikes Peak.

Cow; butte in Otero County; altitude, 4,745 feet ..... Catlin.

Cow; creek in Larimer County, a left-hand branch of Big Thompson Creek.

Cow; creek in Ouray County, a left-hand branch of Uncompahgre River..... Ouray.

Cow; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Cow; spring in Garfield County.

Cowan; station in Jefferson County on Colorado and Southern Railway.

Cowdrey; post village in Larimer County.

Cox; post village in Gunnison County.

Coxcomb; peak in San Juan Mountains on boundary between Hinsdale and Ouray counties; altitude, 13,663 feet..... Ouray.

Coxo; station in Conejos County on Denver and Rio Grande Railroad; altitude, 9,741 feet.

Coyote; creek in San Juan County, a right-hand branch of Rio Navajo.

Coyote; creek in Yuma County, a left-hand branch of North Fork Republican River.

Coyote Basin; valley in Routt County.

Crags; station in El Paso County on Colorado Midland Railway; altitude, 7,005 feet.

Crags, The; summit in Teller County..... Pikes Peak.

Craigs; creek in Park County, a right-hand branch of North Fork South Platte River ..... Platte Canyon.

Craigs; post village in Routt County.

Cramer; station in Fremont County on Florence and Cripple Creek Railway; altitude, 5,893 feet.

Crane Park; station in Lake County on Denver and Rio *Grande Railroad*; altitude, 10,102 feet ..... Leadville.

Atlas sheet.

Crater; lake in Jefferson County; altitude, 8,877 feet..... Jefferson.

Cravens; station in Lake County on Denver and Rio Grande Railroad.

Crawford; gulch in Jefferson County, tributary to Clear Creek. Blackhawk.

Crawford; post village in Delta County; altitude, 6,950 feet.

Creede; city, and county seat of Mineral County on Denver and Rio Grande Railroad; population in 1900, 938; altitude, 8,840 feet.

Crescent; peak in Routt County; altitude, 10,255 feet.

Crescent; station in Boulder County on Denver, Northwestern and Pacific Railway ..... Blackhawk.

Crescent; village in Grand County.

Crescent; village in Larimer County.

Crested; butte in Elk Mountains, Gunnison County; altitude, 12,172 feet ..... Crested Butte.

Crested Butte; post village in Gunnison County on Denver and Rio Grande Railroad; population in 1900, 988; altitude, 8,867 feet ..... Crested Butte.

Crestone; creek in Saguache County, a right-hand branch of Cottonwood Creek, tributary to San Luis Creek.

Crestone; peaks in Sangre de Cristo Range, Saguache County; altitude, 14,233 feet.

Crestone; post village in Saguache County on Denver and Rio Grande Railroad; altitude, 7,871 feet.

Crestone Junction; station in Saguache County on Denver and Rio Grande Railroad; altitude, 7,572 feet.

Creswell; post village in Jefferson County.

Crevasse; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,585 feet.

Crews; station in El Paso County on Atchison, Topeka and Santa Fe Railway.

Cripple; creek in Teller County, a left-hand branch of Oil Creek, tributary to Arkansas River..... Pikes Peak.

Cripple Creek; gold-mining town, the county seat of Teller County, on the Colorado Midland, the Florence and Cripple Creek, and the Midland Terminal railways; population in 1900, 10,147; altitude, 9,591 feet..... Pikes Peak.

Crisman; post village in Boulder County on Colorado and Northwestern Railroad; altitude, 6,276 feet.

Critchell; post village in Jefferson County.

Croft; village in Otero County.

Crook; post village in Logan County on Union Pacific Railroad; altitude, 3,707 feet.

Crooked; creek in Grand County, a left-hand branch of Frazer River, tributary to Grand River.

Crooked Wash; creek in Rio Blanco County, a right-hand branch of White River.

Crookston; post village in Saguache County.

Crookton; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,158 feet.

Crosson; station in Park County on Colorado and Southern Railway; altitude, 7,070 feet ..... Platte Canyon.

Atlas sheet.

Crow; creek in Weld County, a left-hand branch of South Platte River ..... Greeley.

Crow; post village in Pueblo County.

Crowes; station in Hinsdale County on Denver and Rio Grande Railroad.

Crown; mountain on boundary between Hinsdale and San Juan counties ..... Silverton.

Crows Roost; summits in El Paso County, south of Big Springs ..... Big Springs.

Crystal; creek in Hinsdale County, a left-hand branch of Henson Creek, tributary to Lake Fork Gunnison River..... Lake City.

Crystal; creek in Gunnison and Montrose counties, a right-hand branch of Gunnison River.

Crystal; lake in Hinsdale County..... Lake City.

Crystal; lake in Lake County ..... Leadville.

Crystal; peak in Gunnison County..... Crested Butte.

Crystal; peak in San Juan Mountains, Hinsdale County; altitude, 12,927 feet..... Lake City.

Crystal; peak in Teller County; altitude, 9,668 feet ..... Pikes Peak.

Crystal; post village in Gunnison County.

Crystal; spring in Yuma County.

Crystal Creek; station in Montrose County on Denver and Rio Grande Railroad; altitude, 6,821 feet.

Crystal Lake; station in Jefferson County on Colorado and Southern Railway; altitude, 6,873 feet.

Crystal Lake; station in Lake County on Denver and Rio Grande Railroad ..... Leadville.

Crystal River Railroad; line connecting Carbondale and Placita; a narrow-gage spur runs from Redstone to Coalbasin.

Crystal Springs; station in Kit Carson County on Chicago, Rock Island and Pacific Railway.

Cuatro; post village in Las Animas County; altitude, 7,994 feet.

Cub; creek in Jefferson County, a right-hand branch of Bear Creek, tributary to South Platte River.

Cub; mountain in Park County; altitude, 10,623 feet.

Cuba; gulch in Hinsdale County, tributary to Rio Grande.... Silverton

Cuchara; pass between Huerfano and Las Animas counties; altitude, 9,994 feet.

Cuchara; post village in Huerfano County on Denver and Rio Grande Railroad ..... Walsenburg.

Cuchara; river in Huerfano and Pueblo counties, a right-hand branch of Huerfano River. Walsenburg. Huerfano.

Cuchara Junction; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 5,930 feet.

Cuerin; village in Saguache County.

Cuffey; village in Park County.

Culbertson Junction; station in Boulder County on Colorado and Southern Railway.

Culebra; peak in Las Animas County; altitude, 14,069 feet.

Cullom, Mount; in Routt County west of Green River.

Culver; station in El Paso County on Colorado Midland Railway; altitude, 7,503 feet ..... Colorado Springs.

Atlas sheet.

Cumberland; peak in San Juan Range, La Plata County; altitude, 12,368 feet ..... Durango.
Cumberland Basin; valley in La Plata County ..... La Plata.
Cumbres; station in Conejos County on Denver and Rio Grande Railroad; altitude, 10,003 feet.
Cunningham; creek in San Juan County, a left-hand branch of Animas River ..... Silverton.
Cunningham; pass in San Juan Mountains, connecting Bakers Park with the head of Rio Grande; altitude, 12,090 feet.
Cunningham; station in La Plata County on Denver and Rio Grande Railroad.
Cunninghams; station in Summit County on Denver and Rio Grande Railroad.
Curecanti; creek in Gunnison County, a right-hand branch of Gunnison River.
Curecanti; village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,065 feet.
Currant; creek in Fremont County, a left-hand branch of Arkansas River ..... Pikes Peak.
Currant; creek in Rio Blanco County, a left-hand branch of White River.
Currant Creek; pass in Park County; altitude, 9,654 feet.
Currant Creek; village in Fremont County ..... Pikes Peak.
Curtin; station in Summit County on Colorado and Southern Railway; altitude, 9,278 feet.
Curtis; creek in Rio Blanco County, a right-hand branch of White River.
Curtis; post village in El Paso County.
Curtis; station in Summit County on Denver and Rio Grande Railroad.
Curtis; village in Washington County.
Custer; county south of the center of the State; bounded on the north by Fremont County, on the east by Pueblo County, on the south by Huerfano County, and on the west by Sangre de Cristo Range, the slopes of which descend to Grape Creek and include the Wet Mountains, from which the county descends into plains. Its area is 696 square miles, of which 5 per cent, or 23,111 acres, were under cultivation in 1900. The population in 1900 was 2,937; and of Silver Cliff, the county seat, 576. In 1900 the average magnetic declination was 13° 00′ east. The mean annual rainfall is about 17 inches, and the mean annual temperature 40° to 45°.
Cutter; creek in Ouray County, a right-hand branch of Uncompahgre River ..... Ouray.
Cyanide; post village in Fremont County on Florence and Cripple Creek Railroad; altitude, 5,231 feet.
Daffodil; post village in Douglas County.
Dailey; village in Garfield County.
Daisy; pass in Gunnison County ..... Anthracite.
Dale; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Atlas sheet.

Dale; station in Fremont County on Florence and Cripple Creek Railroad; altitude, 7,063 feet.

Dallas; peak in San Miguel County ..... Telluride.

Dallas; town in Ouray County on Denver and Rio Grande Railroad; population in 1900, 50; altitude, 6,909 feet..... Ouray.

Dallas Divide; post village in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,977 feet.

Dallas Fork; in Ouray County, a left-hand branch of Uncompahgre River.

Daly, Mount; in Elk Mountains, Pitkin County; altitude, 13,193 feet.

Dana; creek in Dolores County, a left-hand branch of West Fork Dolores River.

Danforth; hills in Routt and Rio Blanco counties.

Dante; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Darby; creek in La Plata County, a left-hand branch of La Plata River ..... La Plata.

Dark; canyon in Gunnison County, tributary to Anthracite Creek ..... Anthracite.

Davenport; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special

Davenport; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,169 feet.

Davidson; mesa in Boulder County..... Denver.

Davis; canyon in Otero County, tributary to Purgatory River. Timpas.

Davis; peak in Larimer County; altitude, 11,001 feet.

Daweepanoonis; creek in Ouray County, a left-hand branch of Uncompahgre River.

Dawkins; post village in Pueblo County. Railroad name, Piñon.

Dawson; butte in Douglas County..... Castle Rock.

Dawson; station in Jefferson County on Colorado and Southern Railway; altitude, 6,308 feet..... Platte Canyon.

Dayton; village in Gunnison County; altitude, 9,441 feet.

Dead; lake in El Paso County..... Pikes Peak.

Deadman; canyon in El Paso County, tributary to Turkey Creek ..... Colorado Springs.

Deadman; creek in El Paso County, a right-hand branch of Beaver Creek, tributary to Arkansas River..... Castle Rock.

Deadman; gulch in Boulder County, tributary to South St. Vrain Creek ..... Boulder.

Deadman; gulch in Hinsdale County, tributary to Lake Fork Gunnison River..... Lake City

Deadman; gulch in La Plata County, tributary to Cherry Creek ..... La Plata.

Deadmans; gulch in Gunnison County, tributary to Taylor River..... Crested Butte.

Deadwood; creek in La Plata County, a left-hand branch of La Plata River ..... La Plata.

Deadwood; gulch in Dolores County, tributary to East Dolores River ..... Rico.

Atlas sheet.

Deadwood; gulch in San Juan County, tributary to Animas River ..... Silverton.
Deadwood; mountain in La Plata County ..... La Plata.
Dean, post village in Las Animas County.
Dean; station in Fremont County on Atchison Topeka and Santa Fe Railway; altitude, 5,102 feet.
Deane; town in Douglas County.
Deansbury; town in Jefferson County; altitude, 5,859 feet.
De Beque; post town in Mesa County, on the Colorado Midland and the Denver and Rio Grande railroads; population, in 1900, 83; altitude, 4,935 feet.
Deception; creek in Routt County, a left-hand branch of Yampa River.
Decker; station in Weld County on Union Pacific Railroad; altitude, 5,592 feet.
Deep; canyon in Montezuma County, tributary to West Mancos River ..... La Plata.
Deep; creek in Garfield County, a right-hand branch ot Grand River.
Deep; creek in La Plata County, a left-hand branch of Lightner Creek ..... Durango.
Deep; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.
Deep; lake in Garfield County.
Deep Channel; creek in Routt County, a right-hand branch of White River.
Deepcreek; post village in Routt County.
Deer; creek in Gunnison County, a left-hand branch of East River, tributary to Slate River ..... Crested Butte.
Deer; creek in Jefferson County, a left-hand branch of South Platte River ..... Denver.
Deer; creek in Mesa County, a right-hand branch of Gunnison River.
Deer; creek in Ouray County, a right-hand branch of Cow Creek, tributary to Uncompahgre River ..... Ouray.
Deer; creek in Park County, a left-hand branch of South Platte River ..... Georgetown.
Deer; creek in Pitkin County, a right-hand branch of Roaring Fork.
Deercreek; village in Jefferson County.
Deer Creek; canyon in Boulder County, tributary to Lefthand Creek ..... Boulder.
Deer Park; creek in Park County, a left-hand branch of North Fork South Platte River ..... Platte Canyon.
Deer Park; creek in San Juan County, a left-hand branch of Animas River ..... Silverton.
Deer Park; valley in Custer County ..... Canyon City.
Deer Park; valley in Park County ..... Platte Canyon.
Deer Run; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,702 feet.
Deertail Basin; valley in San Miguel County ..... Telluride.
Deer Trail; creek in Adams and Morgan counties, a right-hand branch of Bijou Creek, tributary to South Platte River.

Atlas sheet.

Deer Trail; post village in Arapahoe County on Union Pacific Railroad; altitude, 5,183 feet.

Defiance; village in Garfield County.

Delagua; post village in Las Animas County on Colorado and Southeastern Railway.

Delano; butte in Larimer County.

Delhi; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,050 feet ..... Apishapa.

Del Norte; peak in San Juan Mountains in Rio Grande County; altitude, 13,084 feet.

Del Norte; post town and county seat of Rio Grande County on Denver and Rio Grande Railroad; population in 1900, 705; altitude, 7,868 feet.

Delta; county in the western part of the State; bounded on the north and west by Mesa County on the east by Gunnison County, and on the south by Montrose County. It is traversed by Gunnison River, to which it slopes from plateaus on the north and south. Its area is 1,201 square miles, of which 5 per cent, or 38,016 acres, were under cultivation in 1900. The population in 1900 was 5,487; and of Delta, the county seat, 819. In 1900 the average magnetic declination was 14° 10′ east. The mean annual rainfall is about 11 inches, and the mean annual temperature 45° to 50°.

Delta; post town and county seat of Delta County on Denver and Rio Grande Railroad; population in 1900, 819; altitude, 4,970 feet.

Democrat; mountain in Clear Creek County ..... Georgetown

Democrat Basin; hanging valley in Gunnison County ..... Anthracite.

Denver; county in the north-central part of the State; bounded on the north by Adams County, on the east by Adams and Arapahoe counties, on the south by Arapahoe County, and on the west by Jefferson County. Denver, the county seat, and its suburbs occupy the greater part. Its surface consists of rolling plains, and its area is 87 square miles. In 1900 the average magnetic declination was 13° 25′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 45° to 50°.

Denver; county seat of Denver County; population in 1900, 133,859. It is situated on the plains, 12 miles east of the base of the mountains, on South Platte River, at the mouth of Clear Creek. It is the capital and largest city of the State, and is entered by eight railroads; altitude, 5,184 feet.

Denver and Inter-Mountain Railway; a line running from Denver to Golden, a distance of 13 miles.

Denver and Rio Grande Railroad; main line starting at Denver runs south to Pueblo, and thence along Arkansas River to its head, crosses the Continental Divide at Tennessee Pass, and extends westward to Salt Lake City and Ogden by way of Eagle and Grand river valleys. A branch line at Salida in Arkansas Valley follows closely Gunnison *River* and rejoins the main line at Grand Junction. An-

Atlas sheet.

Denver and Rio Grande Railroad—Continued.
other branch from Poncha Junction traverses the entire length of San Luis Valley, finally reaching Santa Fe. From Montrose a line extends southward along the Uncompahgre River Valley around the west side of San Juan Mountains, through Rico and Durango, and across the southern boundary of the State, to a junction with the Santa Fe branch. From Pueblo a line runs to Trinidad. There are numerous other small branches. The greater part of the system is included in Colorado.

Denver, Lakewood and Golden Railroad; line connecting Denver and Lakewood, a distance of about 19 miles.

Denver Mills; post village in Denver County on Colorado and Southern Railway.

Denver, Northwestern and Pacific Railway; a line running from Denver to Arrow Head, a distance of 76 miles.

Derby; creek in Eagle County, a right-hand branch of Grand River.

Derby; creek in Logan County, a left-hand branch of Horsetail Creek, tributary to South Platte River.

Derby; peak in Garfield County.

Derby; peak in Rio Blanco County.

Derby; station in Adams County on Burlington and Missouri River Railroad ..... Denver.

Deuel; post-office in Morgan County on Union Pacific Railroad. Railroad name, Weldon.

Devils; canyon in Clear Creek County, tributary to Chicago Creek ..... Georgetown.

Devils; canyon in Ouray County, tributary to Nate Creek.... Ouray.

Devils; canyon in Otero County, tributary to Timpas Creek.. Apishapa.

Devils; creek in Archuleta County, a left-hand branch of Rio Piedra.

Devils; creek in Hinsdale County, a left-hand branch of Lake Fork Gunnison River ..... Lake City.

Devils Causeway; narrow ridge in Garfield County, on the summit of White River Plateau.

Devils Head; summit in Douglas County; altitude, 9,348 feet.

Devils Nose; summit in Clear Creek County; altitude, 11,000 feet ..... Georgetown.

Devine; village in Park County.

Dexter; creek in Ouray County, a right-hand branch of Uncompahgre River ..... Ouray.

Dexter; post village in Grand County.

Diamond; hill in San Miguel County ..... Telluride.

Diamond; peak in Routt County; altitude, 9,925 feet.

Dick; station in Weld County on Union Pacific Railroad; altitude, 5,123 feet ..... Greeley.

Dickey; station in Summit County on Colorado and Southern Railway; altitude, 8,987 feet.

Dickman; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Atlas sheet.

Difficult; creek in Pitkin County, a left-hand branch of Roaring Fork, tributary to Grand River ..... Aspen.

Dike; mountain in Huerfano County ..... Huerfano Park.

Dillon; station in Summit County, on the Colorado and Southern and the Denver and Rio Grande railroads; altitude, 8,849 feet.

Diorite; peak in Montezuma County ..... La Plata.

Dippold Basin; valley in Gunnison County ..... Anthracite.

Disappointment; creek in Dolores County, a right-hand branch of West Fork Dolores River.

Diston; station in Kiowa County on Missouri Pacific Railway; altitude, 4,110 feet ..... Lamar.

Dives Basin; valley in San Juan County ..... Silverton.

Divide; creek in Larimer County, a right-hand branch of Thompson Creek.

Divide; creek in Mesa County, a left-hand branch of Grand River, heading in Smoke and West creeks.

Divide; post village in Teller County, on the Colorado Midland and the Midland Terminal railways; altitude, 9,183 feet .. Pikes Peak.

Divide; station in Chaffee County, on the Colorado Midland and the Denver and Rio Grande railroads.

Dix; village in La Plata County on Denver and Rio Grande Railroad; altitude, 8,208 feet ..... La Plata.

Dixon; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,723 feet.

Dixons Mill; station in Boulder County on Burlington and Missouri River Railroad; altitude, 4,895 feet ..... Niwot.

Dodd; post village in Morgan County on Union Pacific Railroad.

Dodd Reservoir; artificial lake in Boulder County ..... Niwot.

Doe; creek in Mineral County, a left-hand branch of Rio Grande.

Dolly Varden; mountain in Hinsdale County ..... Silverton.

Dolomite; town in El Paso County.

Dolores; county in the southwestern part of the State, bounded on the north by San Miguel County, on the east by Ouray and San Juan counties, on the south by Montezuma County, and on the west by Utah. The eastern part consists of high rugged mountains of the San Juan group, and the western part is an arid plateau. The area is 1,000 square miles, of which less than one-half of 1 per cent, or 942 acres, were under cultivation in 1900. The population in 1900 was 1,134; and of Rico, the county seat, 811. In 1900 the average magnetic declination was 13° 30′ east. The mean annual rainfall is about 23 inches, and the mean annual temperature 45° to 50°.

Dolores; mountain in Dolores County; altitude, 13,502 feet .. Rico. Engineer Mountain.

Dolores; plateau in western part of the State, through which Dolores River cuts a canyon.

Dolores; post town in Montezuma County on Denver and Rio Grande Railroad; population in 1900, 108; altitude, 6,945 feet.

Atlas sheet.

Dolores; river in southwestern part of the State, a large left-hand branch of the Grand, heading in the western part of San Juan Mountains and flowing northwest and then nearly north.

Dome; mountain in San Juan County ..... Silverton.

Dome; mountain in Routt County.

Dome; peak in Garfield County; altitude, 12,498 feet.

Dome Rock; station in Jefferson County on Colorado and Southern Railway; altitude, 6,210 feet ..... Platte Canyon

Dome Rock; summit in Teller County ..... Pikes Peak.

Dominguez; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,791 feet.

Doran; post village in Park County. Railroad name, Mudsill.

Dorcas; station in Fremont County on Florence and Cripple Creek Railroad.

Dorchester; post village in Gunnison County.

Dornick; station in Chaffee County on Denver and Rio Grande Railroad.

Dory; hill in Gilpin County; altitude, 9,270 feet ..... Blackhawk.

Dotsero; post village in Eagle County on Denver and Rio Grande Railroad; altitude, 6,157 feet.

Double Spoon; creek in Delta County, a right-hand branch of Gunnison River.

Double Top; mountain in Gunnison County; altitude, 12,192 feet ..... Crested Butte.

Doudy Hollow; valley in Jefferson and Boulder counties, tributary to Coal Creek ..... Blackhawk.

Douglas; county in the central part of the State; bounded on the north by Arapahoe County, on the east by Elbert County, on the south by El Paso and Teller counties, and on the west by Jefferson County. Its surface consists of high rolling plains, the western portion extending into Front Range. The area is 889 square miles, of which 7 per cent, or 39,165 acres, were under cultivation in 1900. The population in 1900 was 3,120; and of Castle Rock, the county seat, 304. In 1900 the average magnetic declination was 13° 25′ east. The mean annual rainfall is about 18 inches, and the mean annual temperature 50° to 55°.

Douglas; creek in Rio Blanco County, a left-hand branch of White River, originating in East Fork and West Douglas Creek.

Douglas; peak in Jefferson County ..... Blackhawk.

Douglas; station in Douglas County on Denver and Rio Grande Railroad; altitude, 6,308 feet.

Dover; station in Weld County; altitude, 5,399 feet.

Downer; post village in Boulder County.

Downing; village in Las Animas County; altitude, 5,450 feet.. Elmoro.

Doyle; arroyo in Pueblo County, tributary to Huerfano River. Apishapa.

Doyle; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,052 feet. Post-office, Doyleville.

Dresden; station in Huerfano County on Denver and Rio Grande Railroad.

Atlas sheet.

Dresden; station on Colorado and Southern Railway; altitude, 5,767 feet.
Drew; village in Gunnison County
Dripping; spring in Las Animas County; altitude, 5,941 feet. Apishapa.
Dry; arroyo in Otero County, a left-hand branch of Timpas Creek, tributary to Arkansas River ..... Timpas.
Dry; creek in Arapahoe County, a left-hand branch of Cherry Creek, tributary to South Platte River ..... Denver.
Dry; creek in Boulder County, inlet of Swede Lakes ..... Niwot.
Dry; creek in Boulder and Weld counties, a right-hand branch of St. Vrain Creek, tributary to South Platte River ..... Niwot.
Dry; creek in Delta County, a right-hand branch of Gunnison River.
Dry; creek in Jefferson County, a left-hand branch of Clear Creek, tributary to South Platte River ..... Blackhawk.
Dry; creek in Montrose County, a left-hand branch of Uncompahgre River.
Dry; creek in Ouray County, a right-hand branch of Uncompahgre River ..... Ouray.
Dry; creek in Pueblo County, a left-hand branch of Arkansas River ..... Pueblo.
Dry; creek in Prowers County, a right-hand branch of Arkansas River ..... Lamar.
Dry; creek in Rio Blanco County, a right-hand branch of White River.
Dry; gulch in La Plata County, tributary to Animas River.... Durango.
Dry; gulch in San Juan County, tributary to Cement Creek... Silverton.
Dry; mountain in Routt County.
Dry Fork; in Garfield County, a right-hand branch of Rifle Creek, tributary to Grand River.
Dry Fork; in La Plata County, a left-hand branch of Lightner Creek, tributary to Animas River ..... Durango.
Dry Fork; in Montrose and Mesa counties, a left-hand branch of Gunnison River.
Dry St. Vrain; creek in Boulder County, a right-hand branch of North St. Vrain Creek, tributary to St. Vrain Creek.... Boulder.
Dubois; post town in Gunnison County; population in 1900, 23.
Duck; creek in Park County, a left-hand branch of West Geneva Creek, tributary to Geneva Creek ..... Georgetown.
Duck; creek in Rio Blanco County, a left-hand branch of Bitter Creek, tributary to White River.
Duck; lake in Clear Creek County; altitude, 11,070 feet..... Georgetown.
Dudley; village in Park County ..... Leadville.
Duffields; station in El Paso County on Colorado Springs and Cripple Creek District Railway; altitude, 9,295 feet.
Dumont; post village in Clear Creek County on Colorado and Southern Railway; altitude, 7,939 feet.
Dump; mountain in Huerfano County ..... Huerfano Park.
Duncan; post village in Las Animas County.
Duncan; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,880 feet.
Duncan; village in Saguache County.
Duncans; village in Boulder County.

Atlas sheet.

Dundee; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,700 feet.

Dune; station in Saguache County on Denver and Rio Grande Railroad; altitude, 7,549 feet.

Dunkley; post village in Routt County.

Dunton; post village in Dolores County.

Dupont; station on Union Pacific Railroad; altitude, 5,134 feet.

Durango; county seat of La Plata County on Denver and Rio Grande Railroad; population in 1900, 3,317; altitude, 6,508 feet ..... Durango.

Duyer; gulch in Gunnison County, tributary to Lake Fork Gunnison River ..... Lake City.

Dwyer; town in Summit County on Colorado and Southern Railway.

Dwyer; village in Park County.

Dyer; mountain in Park County ..... Leadville.

Dyer; town in Teller County on Colorado Springs and Cripple Creek District Railway.

Dyke; post village in Archuleta County on Denver and Rio Grande Railroad.

Eads; post station in Kiowa County on Missouri Pacific Railway; altitude, 4,209 feet ..... Lamar.

Eagalite; village in Mesa County.

Eagle; county in the north-central part of the State; bounded on the north by Routt and Grand counties, on the east by Summit County, on the south by Lake and Pitkin counties, and on the west by Garfield County. The surface consists mostly of high plateaus rising eastward to Front Range, whose summit forms the eastern boundary. Its area is 1,586 square miles, of which 2 per cent, or 19,709 acres, were under cultivation in 1900. The population in 1900 was 3,008; and of Redcliff, the county seat, 256. In 1900 the average magnetic declination was 14° 15′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature about 40°.

Eagle; pass in La Plata County ..... La Plata.

Eagle; peak in Dolores County; altitude, 12,105 feet ..... Rico.

Eagle; post town in Eagle County on Denver and Rio Grande Railroad; population in 1900, 124; altitude, 6,588 feet.

Eagle; river in Eagle County, an important branch of Grand River, heading in Tennessee Pass and flowing nearly north and then west ..... Leadville.

Eagle Knob; summit in Front Range, Boulder County; altitude, 8,426 feet.

Eagle River; mountains in Park Range.

Eagle River; peak in Eagle River Mountains, Eagle County; altitude, 12,648 feet.

Earl; mesa in Las Animas County ..... Elmoro.

Earl; post village in Las Animas County on Atchison, Topeka, and Santa Fe Railway; altitude, 5,681 feet ..... Elmoro.

East; hill in Prowers County ..... Albany.

East; mountain in Routt County; altitude, 7,588 feet.

East; river in Gunnison County, a right-hand branch of Gunnison River.

Atlas sheet.

East Basin; valley in San Miguel County ..... Telluride.

East Beaver; creek in El Paso County, a left-hand branch of Beaver Creek, tributary to Arkansas River. Colorado Springs. Pikes Peak.

East Bijou; creek in Arapahoe and Adams counties, a right-hand branch of Bijou Creek, tributary to South Platte River.

East Bijou; creek in Elbert County, tributary to reservoir near Agate..... Limon.

East Brush; creek in Gunnison County, a right-hand branch of Cascade Creek, tributary to East River ..... Crested Butte.

East Brush; creek in Gunnison County, a left-hand branch of East River, tributary to Gunnison River..... Crested Butte.

East Canon; creek in Larimer county, a right-hand branch of Cache la Poudre River.

East Carrizo; creek in Baca County, a left-hand branch of Carrizo Creek, tributary to Cimarron River ..... Mount Carrizo.

East Cement; mountain in Elk Mountains, Gunnison County; altitude, 12,047 feet ..... Crested Butte.

East Cherry; creek in Douglas County, a right-hand branch of Cherry Creek, tributary to South Platte River..... Castle Rock.

East Dale; post village in Costilla County.

East Dolores; river in Dolores County, right-hand branch of Dolores River. Telluride. Rico.

East Eighteenmile; creek in Fremont County, a left-hand branch of Eighteenmile Creek, tributary to Arkansas River. Pikes Peak.

East Fork; in Gunnison County, a right-hand branch of Blue Creek, tributary to Gunnison River ..... Lake City.

East Fork; in Gunnison County, a right-hand branch of Little Cimarron Creek, tributary to Gunnison River ..... Lake City.

East Fork; in Eagle County, a right-hand branch of Homestake Creek, tributary to Grand River..... Leadville.

East Fork; in La Plata County, a left-hand branch of Hermosa Creek, tributary to Animas River..... Engineer Mountain.

East Fork Arkansas; in Lake County, a left-hand branch of Arkansas River..... Leadville.

East Fork Eagle; in Eagle County, a right-hand branch of Eagle River..... Leadville.

East Geneva; creek in Park County, a right-hand branch of Geneva Creek, tributary to South Platte River..... Georgetown.

East Hovenweep; creek in Montezuma County, a right-hand branch of Hovenweep Creek, tributary to San Juan River.

East Leadville; village in Park County..... Leadville.

East Lost Park; valley in Park County..... Platte Canyon.

East Mancos; town in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,903 feet.

East Maroon; creek in Pitkin County, right-hand branch of Maroon Creek, tributary to Roaring Fork ..... Aspen.

East Milligan; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.

East Oil; creek in Teller County, a left-hand branch of Oil Creek, tributary to Arkansas River ..... Pikes Peak.

Eastonville; post village in El Paso County on Colorado and *Southern Railway*; altitude, 7,219 feet..... Castle Rock.

Atlas sheet.

East Paradox; creek in Montrose County, a right-hand branch of Dolores River.

East River; pass in Gunnison County; altitude, 11,163 feet.

East River; town in Gunnison County on Denver and Rio Grande Railroad.

East Rush; creek in Lincoln County, a left-hand branch of Rush Creek, tributary to Arkansas River. — Limon. Sanborn. Arroyo.

East Salt; creek in Garfield and Mesa counties, a right-hand branch of Grand River.

East Sheep; mountain in Summit County ..... — Tenmile District Special.

East Silver; mesa in La Plata County ..... Needle Mountains.

East Spanish; peak on boundary between Huerfano and Las Animas counties; altitude, 12,708 feet..... Spanish Peaks.

East Troublesome; creek in Grand County, a right-hand branch of Grand River.

East Turkey; creek in El Paso County, a right-hand branch of Turkey Creek, tributary to Arkansas River..... Colorado Springs.

Eaton; creek in Hinsdale County, a right-hand branch of Lake Fork Gunnison River..... Lake City.

Eaton; post town in Weld County on Union Pacific Railroad; population in 1900, 384; altitude, 4,830 feet.

Ebert; station in Arapahoe County on Colorado Eastern Railway.

Echo; creek in Montezuma County, a left-hand branch of West Mancos River..... La Plata.

Echo; lake in Clear Creek County ..... Georgetown.

Echo; mountain in San Juan Mountains, La Plata County; altitude, 13,305 feet..... Needle Mountains.

Echo; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,069 feet.

Eckert; post village in Delta County.

Eckley; post village in Yuma County on Burlington and Missouri River Railroad; altitude, 3,890 feet.

Eclipse; gulch in Clear Creek County, tributary to Chicago Creek ..... Georgetown.

Eclipse; station in Teller County on the Colorado Springs and Cripple Creek District, the Florence and Cripple Creek, and the Midland Terminal railways; altitude, 9,658 feet.

Eddy; post village in Routt County; altitude, 7,906 feet.

Eden; post village in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,870 feet. Railroad name, Bragdon..... Pueblo.

Edgerton; station in El Paso County on Denver and Rio Grande Railroad; altitude, 6,405 feet ..... Colorado Springs.

Edgewater; post village in Jefferson County.

Edith; gulch in San Juan County, tributary to Animas River .. Silverton.

Edith; lake in Clear Creek County; altitude, 10,117 feet..... Georgetown.

Edith; mountain in Hinsdale County ..... Silverton.

Edith; village in Archuleta County on Union Pacific Railroad; population in 1900, 282.

Atlas sheet.

Edlowe; station in Teller County on Colorado Midland Railway; altitude, 8,908 feet.

Edson; arroyo in Pueblo County, a right-hand branch of St. Charles River ..... Pueblo.

Edwards; post village in Eagle County. Railroad name, Allentown.

Egeria; creek in Routt County, a right-hand branch of Grand River.

Egeria; village in Routt County.

Egeria Park; valley in Routt County.

Eggleston; lake in Delta County.

Eighteenmile; creek in Fremont County, a left-hand branch of Arkansas River. ..... Pikes Peak. Canyon City.

Eightmile Park; valley in Fremont County ..... Pikes Peak.

Eiler; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,840 feet.

Eiler Junction; station in Pueblo County on Denver and Rio Grande Railroad.

Elbert; county in the eastern part of the State; bounded on the north by Arapahoe County, on the east by Lincoln County, on the south by El Paso and Lincoln counties, and on the west by Douglas County. The surface consists of rolling plains, traversed by three railroads—the Colorado and Southern, the Chicago, Rock Island and Pacific, and the Union Pacific. The area is 1,852 square miles, of which 3 per cent, or 40,460 acres, were under cultivation in 1900. The population in 1900 was 3,101, and of Kiowa, the county seat, 116. In 1900 the average magnetic declination was 12° 40′ east. The mean annual rainfall is about 17 inches, and the mean annual temperature 50° to 55°.

Elbert; creek in Lake County, a right-hand branch of Half Moon Creek, tributary to Arkansas River ..... Leadville.

Elbert; creek in La Plata County, a left-hand branch of Hermosa Creek ..... Engineer Mountain.

Elbert; post village in Elbert County on Colorado and Southern Railway; altitute, 6,711 feet ..... Castle Rock.

Elbert, Mount; in Sawatch Range, Lake County; altitude, 14,421 feet.

Elbow; canyon in Eagle County, tributary to Eagle River.

Elco; post village in La Plata County.

Elder; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.

Eldora; post town in Boulder County; population in 1900, 395.

Eldred; post village in Fremont County ..... Pikes Peak.

Eldredge; station in Ouray County on Denver and Rio Grande Railroad; altitude, 6,532 feet.

Electric; peak in Sangre de Cristo Range, Custer County; altitude, 13,699 feet.

Electric; peak in San Juan Mountains, San Juan County ..... Needle Mountains.

Elevenmile; canyon in Park County, tributary to South Platte River ..... Pikes Peak.

Elizabeth; post town in Elbert County on Colorado and Southern Railway; population in 1900, 215; altitude, 6,446 feet. Castle Rock.

Atlas sheet.

El Jebel; station in Garfield County on Colorado Midland Railway; altitude, 6,483 feet.

Elk; creek in Conejos County, a right-hand branch of Rio Conejos.

Elk; creek in Eagle County, a right-hand branch of Eagle River ..... Leadville.

Elk; creek in Garfield County, a right-hand branch of Grand River, originating in East, West, and Middle forks.

Elk; creek in Grand County, a left-hand branch of Frazer River, tributary to Grand River.

Elk; creek in Gunnison County, a right-hand branch of Gunnison River.

Elk; creek in Gunnison and Hillsdale counties, a left-hand branch of Lake Fork Gunnison River ..... Lake City.

Elk; creek in Jefferson County, a left-hand branch of Clear Creek, tributary to South Platte River ..... Blackhawk.

Elk; creek in La Plata County, a left-hand branch of Junction Creek, tributary to Animas River ..... Durango.

Elk; creek in Park County, a left-hand branch of South Platte River ..... Georgetown.

Elk; creek in Park and Jefferson counties, a left-hand branch of North Fork South Platte River ..... Platte Canyon.

Elk; creek in Rio Blanco County, a left-hand branch of White River; discharge near Trull, May 2 to October 31, 1904, 293,600 acre-feet.

Elk; creek in San Juan County, a left-hand branch of Animas River ..... Needle Mountains.

Elk; mountain in Grand County; altitude, 11,494 feet.

Elk; mountain on boundary between Eagle and Summit counties; altitude, 12,718 feet ..... Leadville.

Elk; irregular group of mountains west of Sawatch Range, between Grand and Gunnison rivers; many of its peaks exceed 13,000 feet, and a few exceed 14,000 feet. The range is in part composed of sandstone and eruptive rocks.

Elk; river in Routt County, a right-hand branch of Bear River, tributary to Yampa River.

Elk Basin; valley in Gunnison County ..... Anthracite.

Elk Creek; station in Jefferson County on Colorado Midland Railway.

Elk Creek; station on Colorado and Southern Railway; altitude, 6,536 feet.

Elk Head; creek in Routt County, a right-hand branch of Bear River.

Elk Head; mountains in Routt County.

Elkhorn; creek in Routt and Rio Blanco counties, a left-hand branch of Mill Creek, tributary to Yampa River.

Elkhorn; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Elkhorn; post village in Larimer County.

Elko; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,278 feet.

Elko; village in Gunnison County.

Atlas sheet.

Elk Park; station in San Juan County on Denver and Rio Grande Railroad; altitude, 8,868 feet..... Needle Mountains.

Elkton; post village in Teller County, on the Florence and Cripple Creek, the Colorado Midland, and the Midland Terminal railroads; altitude, 9,693 feet..... Pikes Peak.

Elkton; village in Gunnison County ..... Anthracite.

Ellicott; post village in El Paso County.

Elliott; mountain in San Juan Mountains, Dolores County; altitude, 12,337 feet..... Rico.

Ellis; mountain in San Juan Mountains, Dolores County; altitude, 12,516 feet

Elmoro; post village in Las Animas County, on the Denver and Rio Grande, and the Atchison, Topeka and Santa Fe railroads; altitude, 5,841 feet..... Elmoro.

El Paso; county in the east-central part of the State; bounded on the north by Douglas and Elbert counties, on the east by Elbert and Lincoln counties, on the south by Pueblo County, and on the west by Teller and Fremont counties. The surface consists of rolling plains, traversed by railroads in the western part, but the eastern part is sparsely settled. The area is 2,134 square miles, of which 4 per cent, or 62,408 acres, were under cultivation in 1900. The population in 1900 was 31,602, and of Colorado Springs, the county seat, 21,085. In 1900 the average magnetic declination was 13° 20′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 45° to 50°.

El Paso; creek in Hinsdale County, a left-hand branch of Henson Creek, tributary to Lake Fork Gunnison River..... Lake City.

El Paso; town in El Paso County.

Ells; creek in Logan County, a left-hand branch of Horsetail Creek, tributary to South Platte River.

Elsmere; town in El Paso County on Chicago, Rock Island, and Pacific Railway; altitude, 6,410 feet.

Elston; mountain in Dolores County.

Elwood; village in Rio Grande County; altitude, 11,654 feet.

Elyria; village in Denver County; population in 1900, 1,384. Railroad name, Pullman.

Emancipation; hill in Boulder County; altitude, 7,346 feet.. Boulder.

Embargo; creek in Rio Grande County, a left-hand branch of Rio Grande.

Embargo; post village in Saguache County.

Emerald; lake in La Plata County; altitude, 11,270 feet..... Needle Mountains.

Emerson; village in Phillips County.

Emerson, Mount; in San Juan Mountains, La Plata County; altitude, 13,147 feet..... Needle Mountains.

Emery; peak in San Juan County ..... Silverton.

Emery; village in La Plata County ..... Durango.

Emma; post village in Pitkin County; altitude, 6,600 feet.

Emmons, Mount; in Elk Mountains, Gunnison County; altitude, 12,414 feet..... Anthracite.

Empire; gulch in Lake County, tributary to Arkansas River.. Leadville.

Empire; hill in Lake County..... Leadville.

Atlas sheet.

Empire; post village in Clear Creek County on Colorado and Southern Railway; altitude, 8,260 feet.

Empire; town in Teller County on Florence and Cripple Creek Railroad; population in 1900, 276.

Endlich; mesa in La Plata County ..... Needle Mountains.

Engelmann; canyon of Ruxton Creek, above Manitou, El Paso County, tributary to Fountain Creek ..... Colorado Springs.

Engineer; mountain in San Juan Mountains on boundary between Ouray, Hinsdale, and San Juan counties; altitude, 13,190 feet ..... Silverton.

Engineer; mountain in San Juan Mountains, San Juan County; altitude, 12,962 feet ..... Engineer Mountain.

Engle; post village in Las Animas County on Denver and Rio Grande Railroad; altitude, 6,531 feet. Railroad name, Engleville.

Engleville Junction; station in Las Animas County on Denver and Rio Grande Railroad; altitude, 5,868 feet.

Englewood; post village in Arapahoe County.

English; spring in Pueblo County ..... Apishapa.

English; station in Fremont County on Denver and Rio Grande Railroad.

English Gulch; station in Lake County on Denver and Rio Grande Railroad.

Enos; village in Las Animas County.

Enterprise; station in Dolores County on Denver and Rio Grande Railroad; altitude, 9,223 feet.

Eolus, Mount; in San Juan Mountains, La Plata County; altitude, 14,079 feet ..... Needle Mountains.

Erdman; lake in Pueblo County ..... Nepesta.

Erie; lake in Boulder County ..... Niwot.

Erie; post town in Weld County, on the Burlington and Missouri River and the Union Pacific railroads; population in 1900, 697; altitude, 5,029 feet ..... Niwot.

Escalante; river in Montrose and Mesa counties, a left-hand branch of Gunnison River.

Escalante; hill in Routt County.

Escalante; hills in Rio Blanco County.

Escalante; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,835 feet.

Escalante; village in Routt County.

Espinoza; post village in Conejos County.

Estabrook; post village in Park County on Colorado and Southern Railway; altitude, 7,558 feet ..... Platte Canyon.

Estes Cone; summit in Larimer County; altitude, 10,705 feet.

Estes Park; mountain valley with an altitude of 7,000 feet, near the north base of Longs Peak.

Estes Park; post village in Larimer County; altitude, 6,810 feet.

Ethel; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River ..... Georgetown.

Ethel; peak in Larimer County; altitude, 11,976 feet.

Euclid, gulch in La Plata County, tributary to La Plata River. La Plata.

Atlas sheet.

Eula; village in Routt County.
Eureka; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special.
Eureka; gulch in San Juan County, tributary to Animas River ..... Silverton.
Eureka; hill in Cheyenne County ..... Kit Carson.
Eureka; mountain in San Juan County ..... Silverton.
Eureka; post village in San Juan County on Silverton Northern Railroad; population in 1900, 39 ..... Silverton.
Evans; gulch in Lake County, tributary to East Fork Arkansas River ..... Leadville.
Evans; post village in Weld County on Union Pacific Railroad; altitude, 4,652 feet ..... Greeley.
Evans; town in Lake County on Denver and Rio Grande Railroad; population in 1900, 400; altitude, 10,043 feet.
Evans Basin; valley in Gunnison County ..... Anthracite.
Evans, Mount; in Clear Creek County; altitude, 14,321 feet.. Georgetown.
Evans, Mount; in Park Range, Park County; altitude, 13,590 feet ..... Leadville.
Everett; village in Lake County ..... Leadville.
Evergreen; lakes in Lake County ..... Leadville.
Evergreen; post village in Jefferson County.
Eversman; station in Boulder County on Burlington and Missouri River Railroad; altitude, 5,204 feet.
Excelsior; station in Summit County on Denver and Rio Grande Railroad.
Expectation; mountain in San Juan Mountains, Dolores County; altitude, 12,065 feet ..... Rico.
Express; creek in Pitkin County, a right-hand branch of Castle Creek, tributary to Roaring Fork ..... Aspen.
Fair Grounds; town in Las Animas County.
Fairmount; post village in Otero County.
Fairplay; county seat of Park County on Colorado and Southern Railway; population in 1900, 319; altitude, 9,896 feet.
Fairview; gulch in San Juan County, tributary to Cement Creek ..... Silverton.
Fairview; mountain in Gunnison County.
Fairview; peak in Boulder County; altitude, 8,561 feet ..... Boulder.
Fairview; station in El Paso County on Colorado Springs and Cripple Creek District Railway; altitude, 7,913 feet.
Fairview; station in Montrose County on Denver and Rio Grande Railroad; altitude, 6,157 feet.
Falcon; post village in El Paso County, on the Colorado and Southern and the Chicago, Rock Island and Pacific railways; altitude, 6,833 feet ..... Colorado Springs.
Fall; creek in Gunnison County, a left-hand branch of Blue Creek, tributary to Gunnison River ..... Lake City.
Fall; gulch in La Plata County, tributary to La Plata River... La Plata.
Fall; river in Clear Creek County, a left-hand branch of Clear Creek. ..... Idaho Springs Special.
Fall; river in Larimer County, a left-hand branch of Thompson Creek.

Atlas sheet.

Fall Creek; station in San Miguel County on Denver and Rio Grande Railroad, altitude, 7,474 feet.

Fall River; station in Clear Creek County on Colorado and Southern Railway; altitude, 7,679 feet.

Falls; creek in La Plata County, tributary to Animas River... Durango.

Farmers; station in Garfield County on Denver and Rio Grande Railroad.

Farmers Spur; village in Weld County on Colorado and Southern Railway ..... Greeley.

Farnham Spur; town in Summit County on Colorado and Southern Railway; altitude, 11,246 feet.

Farnum, summit in Park County; altitude, 11,400 feet.

Fassbinder; gulch in La Plata County, tributary to Flagler Fork ..... Durango.

Fawn; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Felch; creek in Fremont County, a left-hand branch of Oil Creek, tributary to Arkansas River..... Pikes Peak.

Fergus; station in Kiowa County on Missouri Pacific Railway; altitude, 4,340 feet..... Lamar.

Ferndale; station in Jefferson County on Colorado and Southern Railway.

Fernleaf; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,297 feet.

Findley; creek in Hinsdale County, a left-hand branch of Henson Creek, tributary to Lake Fork Gunnison River ... Lake City.

Finger; mesa on the north of Rio Grande, with a maximum altitude of 12,000 feet, sloping westward to Antelope Park.

First; creek in Adams County, a right-hand branch of South Platte River..... Denver.

First View; station in Cheyenne County on Union Pacific Railroad; altitude, 4,588 feet..... Kit Carson.

Fish; creek in Dolores County, a right-hand branch of West Dolores River, tributary to Dolores River ..... Rico.

Fish; creek in Larimer County, a right-hand branch of Yampa River.

Fish; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Fish; creek in Larimer County, a right-hand branch of Thompson Creek, tributary to South Platte River.

Fish; creek in Park County, a left-hand branch of Twin Creek, inlet of Lake George..... Pikes Peak.

Fish; creek in Routt County, a left-hand branch of Bear River, tributary to Yampa River.

Fisher; peak near Trinidad, Las Animas County; altitude, 9,586 feet ..... Elmoro.

Fisher; post village in Pueblo County.

Fisher; station in Chaffee County on Colorado and Southern Railway; altitude, 9,257 feet.

Fishers; creek in Montezuma County, a right-hand branch of Aztec Spring Creek, tributary to Rio Mancos.

Fishers Mill; station in San Juan County on Silverton, Gladstone and Northerly Railroad.

Atlas sheet.

Flag; creek in Rio Blanco County, a left-hand branch of White River.

Flagler; post village in Kit Carson County, on Chicago, Rock Island and Pacific Railway; altitude, 4,924 feet.

Flagler Fork; in La Plata County, a left-hand branch of Junction Creek, tributary to Animas River ..... Durango.

Flattop; summit in Dolores County; altitude, 12,096 feet..... Engineer Mountain.

Fleming; station in Denver County on Denver and Rio Grande Railroad.

Fleming; post village in Logan County on Burlington and Missouri River Railroad; altitude, 4,235 feet.

Fletcher; mountain in Summit County..... Leadville.

Fletcher; town in Arapahoe County; population in 1900, 202.

Flirtation; peak in Clear Creek County; altitude, 8,278 feet.. Georgetown.

Flora; peak in Front Range; altitude, 12,878 feet.

Flora; village in Sedgwick County.

Florence; city in Fremont County, on the Denver and Rio Grande, the Atchison, Topeka and Santa Fe, and the Florence and Cripple Creek District railways; population in 1900, 3,728; altitude, 5,187 feet..... Canyon City.

Florence and Cripple Creek Railroad; line connecting Florence and Cripple Creek, a distance of 40 miles.

Floresta; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 9,850 feet. Railroad name, Ruby.

Floresta Junction; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,883 feet.

Florida; mountain in San Juan Mountains, La Plata County; altitude, 13,076 feet..... Needle Mountains.

Florida; river in La Plata County, a left-hand branch of Rio Grande. Needle Mountains. Durango.

Florida; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,705 feet.

Florida Mesa; station in La Plata County on Denver and Rio Grande Railroad ..... Durango.

Florissant; post village in Teller County on Colorado Midland Railway; population in 1900, 131; altitude, 8,178 feet..... Pikes Peak.

Flour Mill; station in Garfield County on Denver and Rio Grande Railroad.

Floyd Hill; station in Clear Creek County on Colorado and Southern Railway; altitude, 7,216 feet..... Blackhawk.

Fly by Night; gulch in La Plata County, tributary to La Plata River..... La Plata.

Foin; gulch in La Plata County, tributary to Junction Creek.. Durango.

Fondis; post village in Elbert County.

Foot Log; station in San Miguel County on Denver and Rio Grande Railroad.

Forbes; post village in Las Animas County on Denver and Rio Grande Railroad..... Spanish Peaks.

Forbes Junction; station in Las Animas County on Colorado and Southern Railway; altitude, 6,193 feet..... Spanish Peaks.

Forder; post village in Lincoln County.

Forks; *village in* Larimer County.

Atlas sheet.

Forks Creek; post village in Jefferson County on Colorado and Southern Railway; altitude, 6,893 feet ..... Blackhawk.

Formby; town in Dolores County.

Formby; town in Montezuma County.

Fort Collins; county seat of Larimer County on Colorado and Southern Railway; population in 1900, 3,053; altitude, 4,984 feet.

Fort Garland; post village in Costilla County; altitude, 7,996 feet.

Fortification; creek in Routt County, a right-hand branch of Bear River.

Fortification; village in Routt County.

Fort Lewis; station in La Plata County on Denver and Rio Grande Railroad; altitude, 8,870 feet.

Fort Logan; post village in Arapahoe County on the Colorado and Southern and the Denver and Rio Grande railroads .. Denver.

Fort Morgan; post town and county seat of Morgan County, on the Burlington and Missouri River and the Union Pacific railroads; population in 1900, 634; altitude, 4,338 feet.

Fort Pagosa; springs in Archuleta County.

Fossil; creek in Larimer and Weld counties, right-hand branch of Cache la Poudre River, tributary to South Platte River. Greeley.

Fossil; peak in Gunnison County.

Fossil Creek; station in Larimer County on Colorado and Southern Railway; altitude, 5,110 feet.

Fossil; ridge, west of Sawatch Range, between Gunnison River and Tomichi Creek. The summits slightly exceed 12,000 feet.

Fountain; creek in Pueblo County, a left-hand branch of Arkansas River. Pueblo. Colorado Springs.

Fountain; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Fountain; post village in El Paso County, on the Chicago, Rock Island and Pacific, the Atchison, Topeka and Santa Fe, the Colorado and Southern, and the Denver and Rio Grande railroads; altitude, 5,563 feet ..... Colorado Springs.

Fourmile; creek in Rio Blanco County, a right-hand branch of White River.

Fourmile; creek in Routt County, a left-hand branch of Little Snake River.

Fourmile; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Fourmile; village in Routt County.

Fourteenmile; creek in Rio Blanco County, a right-hand branch of Piceance Creek, tributary to White River.

Fourth of July; creek in Gunnison County, a right-hand branch of Lake Fork Gunnison River..... Lake City.

Fowler; mesa in Las Animas County; altitude, 6,075 feet .... Mount Carrizo.

Fowler; post village in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,330 feet ..... Nepesta.

Fox; creek in Eagle County, a right-hand branch of Turkey Creek, tributary to Arkansas River.

Fox; post village in Yuma County.

Atlas sheet.

Frances; post village in Boulder County on Colorado and Northwestern Railroad.

Franceville; station in El Paso County on Colorado and Southern Railway ..... Colorado Springs.

Franceville Junction; station in El Paso County on Colorado and Southern Railway; altitude, 5,862 feet ..... Colorado Springs.

Francisco; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 7,468 feet.

Franklin; station in Las Animas County on Colorado and Southern Railway; altitude, 6,272 feet.

Franklin Junction; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,788 feet.

Frank Prince; lake in Boulder County ..... Niwot.

Frank Spur; station on Denver and Rio Grande Railroad; altitude, 7,208 feet.

Franktown; post village in Douglas County ..... Castle Rock.

Fraser; post village in Grand County.

Frazer; river in Grand County, a right-hand branch of Grand River.

Fred Rohr; gulch in Pueblo County, tributary to Arkansas River ..... Pueblo.

Fredonia; village in Bent County.

Freedom; post village in Conejos County.

Freeland; post village in Clear Creek County; altitude, 8,914 feet ..... Georgetown.

Freeman; peak in Jefferson County; altitude, 11,627 feet ..... Platte Canyon.

Freemans Spur; station in Eagle County on Colorado Midland Railway.

Freezeout; creek in Las Animas County, a right-hand branch of Two Butte Creek, tributary to Arkansas River ..... Mount Carrizo.

Fremont; county in the south-central part of the State; bounded on the north by Park and Teller counties, on the east by El Paso and Pueblo counties, on the south by Custer and Saguache counties, and on the west by Chaffee County; it is traversed through the center by Arkansas River, most of the way in a deep canyon. The surface consists of an alternation of spurs and valleys sloping toward the river. The eastern part contains much plains country. The area is 1,478 square miles, of which 2 per cent, or 20,512 acres, were under cultivation in 1900. The population in 1900 was 15,636; and of Canyon, the county seat, 3,775. In 1900 the average magnetic declination was 13° 10′ east. The mean annual rainfall is about 12 inches, and the mean annual temperature 40° to 45°.

Fremont; pass in Lake County ..... Leadville.

Fremont; peak in Fremont County ..... Canyon City.

Fremont; station in Eagle County on Denver and Rio Grande Railroad.

Fremont Junction; station in Fremont County on Denver and Rio Grande Railroad.

Fremont Orchard; village in Morgan County.

Fremont Pass; station on Denver and Rio Grande Railroad; ***altitude, 11,820 feet.***

Atlas sheet.

Fremonts; butte in Washington County.

French; creek in Hinsdale County, a right-hand branch of Lake Fork Gunnison River..... Lake City.

French; gulch in Summit County, tributary to Blue River.... Leadville.

French Gulch; station in Lake County on Colorado and Southern Railway.

Freshwater; town in Park County on Colorado Midland Railway; population in 1900, 77; altitude, 8,557 feet. Postoffice, Howbert.

Friend; village in Arapahoe County.

Frijole; creek in Las Animas County, a right-hand branch of Purgatory River, tributary to Arkansas River ..... Elmoro.

Frio; canyon in Las Animas County, tributary to Apishapa River..... Spanish Peaks.

Frisco; post village in Summit County, on the Denver and Rio Grande and the Colorado and Southern railways; altitude, 9,071 feet.

Front Range; easternmost range of the Rocky Mountains in Colorado, extending southward from the north boundary of the State nearly to the Arkansas River; it includes many peaks exceeding 14,000 feet in altitude. On the east it rises by long spurs from the plains.

Frost; village in Arapahoe County.

Frosts; station in Montrose County on Denver and Rio Grande Railroad.

Fruita; post town in Mesa County on Denver and Rio Grande Railroad; population in 1900, 126; altitude, 4,500 feet.

Fruitmere; station in Fremont County; on Denver and Rio Grande Railroad.

Fryer; hill in Lake County..... Leadville.

Frying Pan; creek in Pitkin County, a right-hand branch of Roaring Fork.

Fuego; station in Pueblo County on Denver and Rio Grande Railroad.

Fulford; post village in Eagle County.

Fuller; peak in San Juan Mountains, on boundary between San Miguel and San Juan counties..... Telluride.

Full Moon; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Gabbert; station in Ouray County on Denver and Rio Grande Railroad.

Gaff; village in Kit Carson County.

Gaines; gulch in La Plata County, tributary to Flagler Fork.. Durango

Galatea; post village in Kiowa County on Missouri Pacific Railway; altitude, 4,369 feet..... Arroyo

Galbeth; creek in Pueblo County, a right-hand branch of Rock Creek, tributary to Arkansas River..... Pueblo

Galena; mountain in Elk Mountains, Gunnison County; altitude, 13,290 feet.

Galena; mountain in San Juan Mountains, San Juan County . Silverton.

Galena Lion; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Atlas sheet.

Galien; station in Logan County on Burlington and Missouri River Railroad; altitude, 4,173 feet.

Gallagher; station in Dolores County on Denver and Rio Grande Railroad; altitude, 9,868 feet.

Gallinas; canyon in Baca County, tributary to Cimarron River ..... Springfield.

Game; creek in Eagle County, a right-hand branch of Turkey Creek, tributary to Arkansas River.

Gann; station in Douglas County on Atchison, Topeka and Santa Fe Railway.

Garcia; station in Las Animas County on Colorado and Southern Railway.

Garden of the Gods; station in small valley of the same name in El Paso County on Denver and Rio Grande Railroad, north of Colorado Springs; altitude, 6,217 feet ..... Colorado Springs.

Garden Park; valley in Fremont County ..... Pikes Peak.

Gardens; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,578 feet.

Gardner; post village in Huerfano County; altitude, 7,000 feet. Huerfano Park.

Garfield; county in the northwestern part of the State; bounded on the north by Rio Blanco County, on the east by Routt and Eagle counties, on the south by Mesa and Pitkin counties, and on the west by Utah. Its surface is traversed by Grand River and consists of plateaus, which in the north and south are at great altitudes, gradually sloping to the valley of Grand River. Its area is 3,049 square miles, of which nearly 2 per cent, or 29,002 acres, were under cultivation in 1900. The population in 1900 was 5,835, and of Glenwood Springs, the county seat, 1,350. In 1900 the average magnetic declination was for the eastern part 14° 50′ east, and for the western part 15° 00′ east. The mean annual rainfall is about 11 inches, and the mean annual temperature 45° to 50°.

Garfield; creek in Garfield County, a left-hand branch of Grand River.

Garfield; peak in Elk Mountains, Gunnison County; altitude, 12,136 feet ..... Anthracite.

Garfield; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 9,500 feet.

Garfield, Mount; in San Juan Mountains, San Juan County; altitude, 13,065 feet ..... Needle Mountains.

Garland; station in Costilla County on Denver and Rio Grande Railroad; altitude, 7,924 feet.

Garland Junction; station in Conejos County on Denver and Rio Grande Railroad.

Garner; creek in Saguache County, a left-hand branch of San Luis Creek.

Garnett; post village in Costilla County; altitude, 7,700 feet.

Garos; post village in Park County on Colorado and Southern Railway; altitude, 9,109 feet.

Gary; post village in Morgan County.

Gaskill; mountain in Grand County.

Gaskill; *village in* Grand County.

Atlas sheet.

Gate View; village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,870 feet.

Gateway; post village in Mesa County.

Gato; creek in Conejos County, emptying into a sink.

Gault; post village in Weld County.

Gaynor; lakes in Boulder County..... Niwot.

Gemini; peaks in Park Range, Park County..... Leadville.

Genoa; post village in Lincoln County on Chicago, Rock Island and Pacific Railway; altitude, 5,598 feet.

Geneva; gulch in Park County, tributary to South Platte River.

Geneva Park; valley in Park County..... Georgetown.

George; lake in Park and Jefferson counties..... Pikes Peak.

Georges; creek in Logan County, a left-hand branch of Horsetail Creek, tributary to South Platte River.

Georgetown; city and county seat of Clear Creek County on Colorado and Southern Railroad; population in 1900, 1,418; altitude, 8,507 feet..... Georgetown.

Georgia; gulch in San Juan County, tributary to Cement Creek. Silverton.

Georgia; pass between Park and Summit counties; altitude, 11,476 feet.

Gibbs; peak in La Plata Mountains on boundary between Montezuma and La Plata counties..... La Plata.

Gibson; hill in Summit County..... Leadville.

Gibson; peak in Sangre de Cristo Range, Custer County; altitude, 13,729 feet.

Gibson; ridge in Gunnison County..... Crested Butte.

Gillespie; gulch in Boulder County, tributary to Jim Creek .. Boulder.

Gillett; post town in Teller County on Colorado Midland Railway; population in 1900, 524; altitude, 9,933 feet.

Gilman; post town in Eagle County; population in 1900, 222. Railroad name, Rock Creek.

Gilpin; county in the north-central part of the State, upon the eastern slopes of Front Range; bounded on the north by Boulder County, on the east by Jefferson County, on the south by Clear Creek County, and on the west by Grand County. Its area is 130 square miles, of which 3 per cent, or 2,110 acres, were under cultivation in 1900. The population in 1900 was 6,690; and of Central City, the county seat, 3,114. In 1900 the average magnetic declination was 13° 31′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 40° to 45°.

Gilpin; peak in Ouray County; altitude, 13,682 feet..... Telluride.

Gilpin; post village in Gilpin County.

Gilson; gulch in Clear Creek County, tributary to Clear Creek. Idaho Springs Special.

Glacier; peak in Front Range, Summit County; altitude, 12,654 feet.

Glaciers; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,642 feet.

Glade; station in Douglas County on Denver and Rio Grande Railroad, altitude, 6,496 feet.

Gladstone; peak in San Juan Mountains, San Miguel County. Telluride.

Atlas sheet.

Gladstone; post village in San Juan County, on Silverton, Gladstone and Northern Railroad ..... Silverton.
Gladwyn; village in Archuleta County.
Glasson Spur; station in Summit County on Colorado and Southern Railway.
Glen; post village in Washington County.
Glenbrook; station in Fremont County on Florence and Cripple Creek Railroad; altitude, 8,068 feet.
Glencoe; station in Jefferson County, on the Union Pacific and the Colorado and Southern railways..... Denver.
Glencoe; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,346 feet.
Glen Cove; village in Teller County ..... Pikes Peak.
Glendale; post village in Fremont County ..... Pueblo.
Glendale; village in Boulder County; altitude, 6,835 feet..... Boulder.
Glendevey; post village in Larimer County.
Gleneyre; creek in Larimer County, a right-hand branch of Laramie River.
Gleneyre; post village in Larimer County; altitude, 6,500 feet.
Glen Eyrie; creek in El Paso County, a left-hand branch of Fountain Creek, tributary to Arkansas River..... Colorado Springs.
Glenisle; station in Park County on Colorado and Southern Railway.
Glenmore Lake; station in Jefferson County on Colorado and Southern Railway.
Glenn; village in El Paso County.
Glen Park: station in El Paso County on Denver and Rio Grande Railroad.
Glenwood Springs; county seat of Garfield County, on the Denver and Rio Grande and the Colorado Midland railways; population in 1900, 1,350; altitude, 5,747 feet. Railroad name, Glenwood.
Globe Hill; station in Teller County on Colorado Midland Railway ..... Pikes Peak.
Globeville; town in Arapahoe County on Colorado and Southern Railway; population in 1900, 2,192.
Goat; butte in Pueblo County ..... Pueblo.
Godfrey; station in Delta County on Denver and Rio Grande Railroad.
Godfrey; station in Elbert County on Union Pacific Railroad; altitude, 5,602 feet..... Limon.
Godiva; ridge in Routt County.
Goff; post village in Kit Carson County.
Gold; creek in Elbert County, a left-hand branch of Running Creek, tributary to Boxelder Creek ..... Castle Rock.
Gold; hill in Boulder County; altitude, 8,297 feet ..... Boulder.
Gold; hill in Gunnison County; altitude, 9,500 feet.
Gold; hill in San Miguel County ..... Telluride.
Gold; hill in Teller County ..... Cripple Creek Special.
Gold; lake in Boulder County; altitude, 8,600 feet ..... Boulder.
Gold Basin; valley in Gunnison County ..... Anthracite.

Atlas sheet.

Golden; city and county seat of Jefferson County on Colorado and Southern Railway; population in 1900, 2,152; altitude, 5,692 feet ..... Denver.

Golden; peak in Boulder County; altitude, 9,650 feet ..... Blackhawk.

Golden Age; hill in Boulder County; altitude, 8,400 feet .... Boulder.

Golden Circle Railroad; a line running from Victor to Vista Grande, a distance of 6 miles.

Golden Glen; gulch in Clear Creek County, tributary to Chicago Creek ..... Georgetown.

Golden Horn; summit in San Juan County ..... Telluride.

Goldfield; post town in Teller County, on the Colorado Springs and Cripple Creek District and the Florence and Cripple Creek railroads; population in 1900, 2,191; altitude, 9,882 feet ..... Pikes Peak.

Gold Hill; post village in Boulder County on Colorado and Northwestern Railway; altitude, 8,599 feet ..... Boulder.

Gold Pan; station in Summit County on Colorado and Southern Railway.

Goliath; peak in Clear Creek County ..... Georgetown.

Goodnight; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,731 feet.

Goodpasture; post village in Pueblo County.

Goodrich; station in Morgan County on Union Pacific Railroad.

Good Spring; creek in Routt and Rio Blanco counties, a left-hand branch of Yampa River.

Goose; creek in Gunnison County, a left-hand branch of Gunnison River.

Goose; lake in Huerfano County ..... Huerfano Park.

Gordon; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Gordon; gulch in Boulder County, tributary to North Boulder Creek ..... Boulder.

Gordon; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,320 feet.

Gore; canyon in Park Range, through which Grand River escapes from Middle Park.

Gore; creek in Eagle County, a right-hand branch of Eagle River.

Gore; mountains in Eagle County.

Gore; pass in Grand County; altitude, 9,570 feet.

Gorge; station in Fremont County on Denver and Rio Grande Railroad; altitude, 5,482 feet.

Gorham; post village in Boulder County. Railroad name, Marshall.

Gory; village in Delta County.

Gothic; mountain in Gunnison County; altitude, 12,646 feet.. Anthracite.

Gothic; town in Gunnison County; altitude, 9,474 feet..... Crested Butte.

Governor; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Grabiola; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,310 feet.

Atlas sheet.

Grace; creek in Larimer County, a left-hand branch of Laramie River.

Graham; creek in Eagle and Pitkin counties, a right-hand branch of Frying Pan Creek, tributary to Roaring Fork.

Graham Park Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 10,605 feet.

Granada; creek in Prowers County, a right-hand branch of Arkansas River. Albany. Granada.

Granada; post town in Prowers County on Atchison, Topeka and Santa Fe Railway; population in 1900, 204; altitude, 3,493 feet ..... Granada.

Granby; post village in Grand County.

Grand; county in the north-central part of the State; bounded on the north by Larimer County, on the east by Front Range, on the south by Williams River Mountains, and on the west by Routt County. The area includes Middle Park, an elevated region limited on the east by Front Range and on the west by Park Range, and is traversed by numerous shorter ranges of mountains. It contains the headwaters of Grand River. Its area is 1,873 square miles, of which 2 per cent, or 18,504 acres, were under cultivation in 1900. The population in 1900 was 741, and of Sulphur Springs, the county seat, 106. In 1900 the average magnetic declination was 14° 10′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 40° to 45°.

Grand; lake in Middle Park, at the source of Grand River.

Grand; mesa in the western part of the State, lying between Grand and Gunnison rivers; altitude, 10,000 feet.

Grand; river in Colorado and Utah, one of the two forks of Colorado River. It heads in the western slopes of Front Range in Middle Park, traverses that high mountain valley with a westerly course, cuts through the Park Range, which forms its western wall, and after a long course, generally toward the southwest, in which it cuts through numerous ranges and plateaus, it joins Green River, forming the Colorado. This river has two forks, known as **East Fork** and **North Fork** of the **Grand**. The discharge at Glenwood Springs for 1904 was 2,049,000 acre-feet; near Palisades, April 1 to October 31, 1904, 2,944,000 acre-feet.

Grand Canyon of the Arkansas; in Fremont County, beginning just above Canyon and extending up the river 6 miles; its depth ranges from 1,000 to 2,000 feet.

Grand Junction; county seat of Mesa County on Denver and Rio Grande Railroad; population in 1900, 3,503; altitude, 4,573 feet.

Grand Lake; post village in Grand County; altitude, 8,153 feet.

Grand River; valley of Grand River extending for some 50 miles below the junction of Grand and Gunnison rivers at Grand Junction, having a breadth of 12 to 18 miles. The river closely hugs the foot of the plateau on the south, the *entire valley* lying on the right-hand side of the stream.

Atlas sheet.

Grand River—Continued.
On the north the valley is limited by the Cliffs of Roan or Book Plateau, which rise 4,000 or 5,000 feet precipitously above it. The only water in the valley is Grand River.
Grand Turk; summit in San Juan County ..... Silverton.
Grand Valley; post village in Garfield County.
Grand View; station in Ouray County on Denver and Rio Grande Railroad.
Graneros; creek in Pueblo County, a right-hand branch of Greenhorn Creek, tributary to St. Charles River..... Walsenburg.
Graneros; post village in Pueblo County on Denver and Rio Grande Railroad; altitude, 5,792 feet ..... Walsenburg.
Granger; station in Rio Grande County on Denver and Rio Grande Railroad.
Grangle; valley in Larimer County; altitude, 8,499 feet.
Granite; gulch in Lake County, tributary to Arkansas River . Leadville.
Granite; hills in Hayden Park, Teller County; altitude, 10,550 feet.
Granite; peak in Chaffee County.
Granite; post town in Chaffee County on the Colorado Midland and the Denver and Rio Grande railroads; population in 1900, 250; altitude, 8,930 feet. Railroad name, Granite Gate ..... Leadville.
Granite Basin; high mountain valley in Gunnison County... Crested Butte.
Grant; creek in Mesa County, a right-hand branch of Dolores River.
Grant; post village in Park County on Colorado and Southern Railway; altitude, 8,566 feet.
Grape; creek in Fremont County, a right-hand branch of Arkansas River..... Canyon City.
Grape; creek in Teller County, a left-hand branch of Twin Creek ..... Pikes Peak.
Grass; valley in Clear Creek County ..... Idaho Springs Special.
Grassy; creek in Teller County, a left-hand branch of Beaver Creek, tributary to Arkansas River. Cripple Creek Special.
Grassy; gulch in San Juan County, tributary to Cement Creek. Silverton.
Grassy; mountain in Hinsdale County..... San Cristobal.
Grassy; village in Teller County on Colorado Springs and Cripple Creek District Railway. Cripple Creek Special.
Gravel; mountain in Hinsdale County ..... Silverton.
Graveline; gulch in Summit County, tributary to Tenmile River. Tenmile District Special.
Graveline; station in Summit County on Denver and Rio Grande Railroad. Tenmile District Special.
Graveyard; creek in Bent County, a left-hand branch of Arkansas River..... Lamar.
Gray; hills in Rio Blanco and Routt counties.
Grayback; gulch in Costilla County, tributary to Placer Creek. Huerfano Park.
Grayback; peak in Sangre de Cristo Range; altitude, 12,387 feet..... Huerfano Park.
Gray Copper; gulch in Ouray County, tributary to Red Mountain Creek..... Silverton.

Atlas sheet.

Gray Creek; post village in Las Animas County, on the Denver and Rio Grande and the Colorado and Southern railroads ..... Elmoro.

Gray Head; summit in San Juan Mountains, San Miguel County; altitude, 10,994 feet ..... Telluride.

Grays; peak in Front Range, Summit County; altitude, 14,341 feet.

Grays; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 9,663 feet.

Grays Basin; hanging valley in San Juan Mountains, San Miguel County.

Graystone; peak in San Juan Mountains, San Juan County; altitude, 13,489 feet ..... Needle Mountains.

Greaser; creek in Huerfano County, a right-hand branch of Muddy Creek, tributary to Huerfano River ..... Huerfano Park.

Great Hogback; summit at east base of Front Range; altitude, 7,923 feet.

Great Hogback Range; ridge in the western part of the State, extending in a sinuous course from Grand River to White River; altitude, 6,000 feet.

Greeley; county seat of Weld County, on the Colorado and Southern and the Union Pacific railroads; population in 1900, 3,023; altitude, 4,652 feet ..... Greeley.

Green; lake in Clear Creek County; altitude; 9,932 feet ..... Georgetown.

Green; mountain in Jefferson County; altitude, 10,530 feet... Platte Canyon.

Green; river in Wyoming, Colorado, and Utah. It heads in Wind River Range in Wyoming, flows southward through Green River basin, cuts a canyon through Uinta Range, and flows for a few miles in Colorado. It then flows in a southward course through a succession of canyons cut in inclined plateaus to its union with Grand River in eastern Utah to form the Colorado.

Green; station in El Paso County on Colorado Midland Railway ..... Pikes Peak.

Greenback; mountain in San Miguel County ..... Telluride.

Greenhalgh; mountain in San Juan County ..... Silverton.

Greenhorn; creek in Pueblo County, a right-hand branch of St. Charles River ..... Walsenburg.

Greenhorn; mountain in Wet Mountains, Huerfano County; altitude, 12,334 feet ..... Huerfano Park.

Greenhorn; post village in Pueblo County ..... Walsenburg.

Greenland; post village in Douglas County on Denver and Rio Grande Railroad; altitude, 6,907 feet ..... Castle Rock.

Greenleaf; creek in Fremont County, a left-hand branch of Texas Creek, tributary to Arkansas River.

Greenlee; spring in Pueblo County ..... Pueblo.

Green Mountain Falls; post village in El Paso County on Colorado Midland Railway; population in 1900, 40; altitude, 7,728 feet ..... Pikes Peak.

Greenwood; post village in Custer County ..... Canyon City.

Gregory; canyon in Boulder County, tributary to Boulder Creek ..... Blackhawk.

Atlas sheet.

Gregory; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special
Gregory; hill in Gilpin County..... Central City Special.
Gresham; post village in Boulder County; altitude, 8,435 feet. Boulder.
Grey Creek; station in Las Animas County on Colorado and Southern Railway.
Greylock; mountain in La Plata County; altitude, 13,571 feet. Needle Mountains.
Griffith; mountain in Clear Creek County; altitude, 11,427 feet. Georgetown.
Grippe; station in Summit County on Colorado and Southern Railway.
Grizzly; canyon in Garfield County, tributary to Eagle River.
Grizzly; gulch in Hinsdale County, tributary to Silver Creek. San Cristobal.
Grizzly; gulch in La Plata County, tributary to Johnson Creek. Needle Mountains.
Grizzly; peak in La Plata County; altitude, 13,695 feet..... Needle Mountains.
Grizzly; peak in San Juan Mountains on boundary line between San Juan and Dolores counties; altitude, 13,748 feet. Telluride.
Grizzly; peak in Sawatch Range, Pitkin County; altitude, 13,956 feet.
Grizzly; station in Garfield County on Denver and Rio Grande Railroad.
Grommet; post village in La Plata County.
Grote; station in Prowers County on Atchison, Topeka and Santa Fe Railway; altitude, 3,527 feet. Post-office, Carlton.
Ground Hog; creek in Dolores County, a right-hand branch of West Dolores River, tributary to Dolores River..... Rico.
Ground Hog; gulch in San Miguel County, tributary to East Dolores River ..... Telluride.
Grouse; gulch in San Juan County, tributary to Animas River..... Silverton.
Grouse; hill in Teller County; altitude, 9,824..... Pikes Peak.
Grove; creek in Delta and Mesa counties, a left-hand branch of Plateau Creek, tributary to Grand River.
Grover; post village in Weld County on Burlington and Missouri River Railroad; altitude, 5,076 feet.
Grover; village in Pueblo County.
Grubbs; station in Garfield County on Crystal River Railroad; altitude, 6,241 feet.
Guajatoyan; creek in Las Animas County, a left-hand branch of Purgatory River ..... Spanish Peaks.
Guardian, The; summit in San Juan County; altitude, 13,617 feet ..... Needle Mountains.
Guero, Mount; in Gunnison County; altitude, 11,749 feet.
Guffey; post village in Park County.
Gulch; post village in Pitkin County; altitude 8,200 feet. Railroad name, Spring Gulch.
Gulf Junction; station in Pueblo County, on the Colorado and Southern, and the Denver and Rio Grande railroads; altitude, 4,623 feet.
Gulnare; post village in Las Animas County..... Spanish Peaks.
Gunbarrel; hill in Boulder County; altitude, 5,384 feet..... Niwot.
Gunnison; county in the west-central part of the State; bounded on the north by Elk Mountain and Pitkin and Mesa coun-

Atlas sheet.

Gunnison—Continued.
ties, on the east by the summit of Sawatch Mountains, on the south by Saguache and Hinsdale counties, and on the west by Delta, Montrose, and Ouray counties. The middle portion is mountainous, comprising short ranges and groups of the Elk Mountains. The northern and southern portions are plateau-like in character. Its area is 3,277 square miles, of which 1 per cent, or 28,163 acres, were under cultivation in 1900. The population in 1900 was 5,331; and of Gunnison, the county seat, 1,200. In 1900 the average magnetic declination was 13° 45′ east. The mean annual rainfall is about 9 inches, and the mean annual temperature 40° to 45°.

Gunnison; mountain in Gunnison County; altitude, 12,688 feet.

Gunnison; post town and county seat of Gunnison County, on the Denver and Rio Grande and the Colorado Midland railways; population in 1900, 1,200; altitude, 7,673 feet.

Gunnison; river, a large right-hand fork of Grand River, heading in the western slopes of Sawatch Range, and flowing west and northwest to Grand Junction; discharge at Whitewater January 1 to October 31, 1904, 121,000 acre-feet.

Gunnison Forest Reserve; area 1,408 square miles.

Guston; station in Ouray County on Silverton Railroad ..... Silverton.

Gutshalls; station in Ouray County on Denver and Rio Grande Railroad.

Guy; gulch in Jefferson County, tributary to Clear Creek .... Blackhawk.

Guy; hill in Jefferson County; altitude, 8,093 feet ..... Blackhawk.

Guy Gulch; station in Jefferson County, on Colorado and Southern Railway; altitude, 6,227 feet.

Guyot; hill in Teller County; altitude, 9,894 feet..... Cripple Creek Special.

Guyot, Mount; in Summit County; altitude, 13,565 feet.

Guys; village in Las Animas County.

Gypsum; creek in Eagle County, a left-hand branch of Eagle River.

Gypsum; creek in San Miguel County, a right-hand branch of Dolores River.

Gypsum; post village in Eagle County on Denver and Rio Grande Railroad; population in 1900, 76; altitude, 6,315 feet.

Gypsum; valley in the western part of the State, drained by Dolores River.

Hackberry; creek in Bent, Las Animas, and Baca counties, a right-hand branch of Rule Creek, tributary to Arkansas River..... Higbee.

Hagens; station in Ouray County on Denver and Rio Grande Railroad; altitude, 7,396 feet.

Hague; peak in Larimer County; altitude, 13,832 feet.

Hahns; peak in Park Range, Routt County.

Hahns Peak; post village and county seat of Routt County; population in 1900, 46.

Hale; post village in Yuma County.

Halfmile; gulch in Jefferson County, tributary to Clear Creek.. Blackhawk.

Atlas sheet.

Half Moon; creek in Lake County, a right-hand branch of Arkansas River ..... Leadville.
Halfway; post village in El Paso County.
Halfway; station in Park County on Colorado and Southern Railway; altitude, 10,539 feet.
Hall; station in Archuleta County on Denver and Rio Grande Railroad.
Hall; station in El Paso County on Atchison, Topeka and Santa Fe Railroad.
Halls; gulch in Park County, tributary to South Platte River.
Halls; station in Gunnison County on Denver and Rio Grande Railroad.
Hall Valley; village in Park County.
Hambline; lake in Boulder County..... Niwot.
Hamilton; canyon in Montrose and San Miguel counties, tributary to San Miguel River.
Hamilton; creek in Grand County, a right-hand branch of Frazer River, tributary to Grand River.
Hamilton; post village in Routt County.
Hamilton, Mount; in Front Range, Park County; altitude, 13,800 feet.
Hammond; town in Park County.
Hancock; gulch in San Juan County, tributary to Cement Creek ..... Silverton.
Hancock; peak in Gunnison County..... Anthracite.
Hancock; post village in Chaffee County.
Hancock; station in Gunnison County, on Colorado and Southern Railway; altitude, 10,015 feet.
Handies; peak in San Juan Mountains, Hinsdale County; altitude, 14,008 feet..... Silverton.
Hangmans; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.
Hanson; peak in San Juan Mountains, San Juan County..... Silverton.
Hantz; peak in Park Range, near northern boundary of the State; altitude, 10,906 feet.
Happy Canyon; creek in Douglas and Arapahoe counties, a left-hand branch of Cherry Creek, tributary to South Platte River..... Denver.
Harbison; creek in Garfield County, a left-hand branch of Parachute Creek, tributary to Grand River.
Hardin; post village in Weld County on Union Pacific Railroad; altitude, 4,525 feet.
Hardscrabble; creek in Fremont and Custer counties, a right-hand branch of Arkansas River..... Canyon City.
Harman; village in Denver County.
Harps; town in Chaffee County.
Harris; post village in Adams County, on the Burlington and Missouri River and the Colorado and Southern railways; altitude, 5,354 feet.
Harrisburg; post village in Washington County.
Harrison; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Atlas sheet.

Harrison; creek in Routt County, a right-hand branch of Bear Creek.

Harrison; post village in Routt County.

Harrison; town in Summit County on Colorado and Southern Railway.

Harrison Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 10,144 feet.

Hartman; gulch in Montezuma County, tributary to McElmo Creek.

Hartsel; post village in Park County on Colorado Midland Railway; altitude, 8,875 feet.

Harvard, Mount; in Sawatch Range, Chaffee County; altitude, 14,375 feet.

Haskill; post village in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,836 feet.

Hastings; post village in Las Animas County on spur of Colorado and Southern Railway ..... Spanish Peaks.

Haswell; post village in Kiowa County on Missouri Pacific Railway; altitude, 4,528 feet ..... Las Animas.

Hatcher; station in Archuleta County on Denver and Rio Grande Railroad.

Hatchery; station in Arapahoe County on Union Pacific Railroad ..... Denver.

Hathaway; station in Douglas County on Denver and Rio Grande Railroad.

Hathaways; town in Summit County.

Haver; station in Park County on Colorado Midland Railway; altitude, 8,977 feet.

Haverly; station in Gunnison County on Denver and Rio Grande Railroad.

Haviland; station in Jefferson County on Colorado and Southern Railway.

Haworth; village in Larimer County.

Hawn; mountain in San Juan Mountains, San Miguel County. Telluride.

Haxtum; post village in Phillips County on Burlington and Missouri River Railroad; altitude, 4,033 feet.

Hay Claim; small park between Turkey Creek and South Platte River.

Hayden; butte in Huerfano County; altitude, 6,860 feet..... Walsenburg.

Hayden; creek in Fremont County, a right-hand branch of Arkansas River.

Hayden; pass between Fremont and Saguache counties; altitude, 10,780 feet.

Hayden; peak in Elk Mountains in Pitkin County..... Aspen.

Hayden; post village in Routt County.

Hayden; station in Lake County on Colorado Midland Railway; altitude, 9,180 feet ..... Leadville.

Hayden, Mount; in San Juan Mountains, Ouray County .... Silverton.

Hayden Park; an elevated tract near the heads of Fountain and Twin creeks, a few miles north of Pikes Peak; average elevation, 10,000 feet.

Hayes; station in Costilla County on Denver and Rio Grande *Railroad;* altitude, 7,525 feet.

Atlas sheet.

Hayford; station in Logan County on Union Pacific Railroad.
Hayman; post village in Park County.
Haynes; creek in Pueblo County, a right-hand branch of Arkansas River ..... Nepesta.
Hay Ranch; station on Colorado and Southern Railway; altitude, 9,314 feet.
Haystack; butte in Pueblo County; altitude, 5,318 feet ..... Apishapa.
Haystack; mountain in Boulder County; altitude, 5,596 feet.. Niwot.
Haywood; station in Rio Grande County on Denver and Rio Grande Railroad; altitude, 7,744 feet.
Hazel; lake in La Plata County; altitude, 12,420 feet..... Needle Mountains.
Hazeltine; post village in Adams County on Union Pacific Railroad; altitude, 5,178 feet.
Hazelton; mountain in San Juan Mountains, San Juan County. Silverton.
Hebron; post village in Larimer County.
Hecla; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,371 feet.
Hecla Junction; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,358 feet.
Helena; canyon in Fremont County, tributary to Oil Creek.. Pikes Peak.
Hell; canyon in Gunnison County, tributary to Lake Fork Gunnison River ..... Lake City.
Hell; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.
Hell Gate; creek in Kit Carson County, a left-hand branch of South Fork Republican River.
Helmet; peak in La Plata Mountains, Montezuma County; altitude, 11,976 feet..... La Plata
Hematite; gulch in San Juan County, tributary to Animas River..... Silverton.
Henderson; island in South Platte River, in Adams County.. Denver.
Henderson; post village in Adams County on Union Pacific Railroad; altitude, 5,039 feet ..... Denver.
Hendrick; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.
Hendricks; station in Fremont County on Denver and Rio Grande Railroad.
Henkel; station in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 5,194 feet. Post-office, Wigwam.
Henrietta; gulch in San Juan County, tributary to Cement Creek ..... Silverton.
Henry; station in Conejos County on Denver and Rio Grande Railroad.
Henson; creek in Hinsdale County, a left-hand branch of Lake Fork Gunnison River, originating in North Fork.... Lake City.
Henson; post village in Hinsdale County ..... Lake City.
Herman, Mount; in El Paso County ..... Castle Rock.
Hermano; peak in Montezuma County; altitude, 9,014 feet.
Hermit; post village in Hinsdale County.
Hermitage; post village in Dolores County.
Hermosa; creek in La Plata County, a right-hand branch of Animas River, *originating in* North and South forks. Durango. Engineer Mountain.

Atlas sheet.

Hermosa; mountain in San Juan Mountains, Dolores County; altitude, 12,564 feet ..... Engineer Mountain.
Hermosa; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,633 feet ..... Durango.
Hermosa Park; high valley in La Plata County; altitude, 8,797 feet ..... Engineer Mountain.
Herrick; station in Pueblo County on Atchison, Topeka and Santa Fe Railway; altitude, 4,741 feet.
Herring; creek in Park county, a right-hand branch of South Platte River.
Herring, Mount; in Custer County; altitude, 9,340 feet ..... Canyon City.
Herron; hill in Las Animas County; altitude, 5,924 feet..... Elmoro.
Hesperus; peak in La Plata Mountains, Montezuma County; altitude, 13,225 feet..... La Plata.
Hesperus; post village in La Plata County on Denver and Rio Grande Railroad; altitude, 8,113 feet ..... La Plata.
Hessie; village in Boulder County.
Hester; post village in Otero County.
Hezron; post village in Huerfano County on Colorado and Western Railway; altitude, 4,999 feet.
Hezron Junction; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 4,857 feet.
Hicks; post village in Las Animas County..... Spanish Peaks.
Hidden; lake in La Plata County ..... Needle Mountains.
Hierro; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,530 feet.
Higbee; canyon in Otero County, tributary to Purgatory River. Higbee.
Higbee; post village in Otero County..... Higbee.
Higgins Park; valley in Boulder County ..... Boulder.
High; creek in Park, Teller, and Fremont counties, a right-hand branch of Oil Creek, tributary to Arkansas River.... Pikes Peak.
Highland; lake in Weld County..... Niwot.
Highland; station in Boulder County on Colorado and Southern Railway; altitude, 5,122 feet..... Niwot.
Highland; village in Pitkin County..... Aspen.
Highland Lake; post village in Weld County ..... Niwot.
Highland No. 2; lake in Boulder County..... Niwot.
Highland Park; valley in Clear Creek County; altitude, 11,000 feet ..... Georgetown.
Highlands; village in Denver County.
High Line Junction; station in Teller County on Colorado Springs and Cripple Creek District Railway.
Highmore; post village in Garfield County.
Higho; post village in Larimer County.
High Park; post village in Teller County ..... Pikes Peak.
Hill; creek in Grand County, a right-hand branch of Muddy Creek, tributary to Grand River.
Hill; gulch in Boulder County, tributary to Jim Creek..... Boulder.
Hillden; station in Saguache County on Denver and Rio Grande Railroad.
Hillrose; post village in Morgan County on Burlington and Missouri River Railroad; altitude, 4,177 feet.
Hillsboro; village in Weld County ..... Greeley.

Atlas sheet.

Hillside; post village in Fremont County on Denver and Rio Grande Railroad; altitude, 7,473 feet.

Hillside; village in Ouray County; altitude, 8,269 feet.

Hilltop; post village in Douglas County on Colorado and Southern Railway.

Hilltop; station in Elbert County on Colorado and Southern Railway ..... Castle Rock.

Hilltop; station in Park County, on the Colorado and Southern and the Colorado Midland railways; altitude, 6,609 feet.

Hilltop Junction; station in Park County on Colorado and Southern Railway; altitude, 9,839 feet.

Hilton; station in Bent County on Atchison, Topeka and Santa Fe Railway; altitude, 3,888 feet.

Hinkles; station in Gunnison County on Colorado and Southern Railway; altitude, 8,174 feet.

Hinsdale; county in the southwestern part of the State; bounded on the north by Gunnison County, on the east by Saguache and Mineral counties, on the south by Archuleta County, and on the west by Ouray, San Juan, and La Plata counties. It includes a portion of San Juan Mountains. Its area is 1,003 square miles, of which 3 per cent, or 1,767 acres, were under cultivation in 1900. The population in 1900 was 1,609; and of Lake City, the county seat, 700. In 1900 the average magnetic declination was 13° 25′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 40°.

Hiram Prince; lake in Boulder County ..... Niwot.

Hirst; village in Costilla County.

Hobart; village in Teller County.

Hoehne; post village in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,711 feet.

Hoffman; lake in Boulder County ..... Niwot.

Hogback; canyon in Mesa County, tributary to Grand River.

Hogback; mesa in Rio Grande County.

Hogback; mountain in Pueblo County ..... Pueblo.

Hogback; summit in Montezuma County ..... La Plata.

Hogback; valley in Routt County.

Hogg; post village in Montezuma County.

Hogland; creek in Saguache County, a right-hand branch of Saguache River.

Hog Ranch; canyon in Pueblo County, tributary to Huerfano River ..... Apishapa.

Holbert Cabin; village in Fremont County ..... Pikes Peak.

Holcolm; hills in El Paso County ..... Big Springs.

Holly; post town in Prowers County on Atchison, Topeka and Santa Fe Railway; population in 1900, 364; altitude, 3,387 feet ..... Granada.

Hollywood; station in Teller County on Florence and Cripple Creek Railroad; altitude, 9,698 feet.

Holtwold; village in Elbert County ..... Big Springs.

Holy Cross; village in Eagle County ..... Leadville.

Holy Cross Forest Reserve; area 1,548 square miles.

Atlas sheet.

Holy Cross, Mountain of the; in Sawatch Range, Eagle County; altitude, 14,170 feet..... Leadville.

Holyoke; post town in Phillips County on Burlington and Missouri River Railroad; altitude, 3,737 feet.

Homans Park; name applied to the northern end of San Luis Valley.

Home; station in Rio Grande County on Denver and Rio Grande Railroad; altitude, 6,547 feet.

Home; village in Larimer County.

Homestake; creek in Eagle County, a left-hand branch of Eagle River, tributary to Grand River..... Leadville.

Homestake; peak in Sawatch Range, on boundary between Pitkin and Eagle counties; altitude, 13,227 feet..... Leadville.

Honnold; village in Routt County; altitude, 9,158 feet.

Hooker; hills in Pueblo County; altitude, 4,907 feet..... Nepesta.

Hooks; station in Pitkin County on Denver and Rio Grande Railroad.

Hooper; post town in Costilla County on Denver and Rio Grande Railroad; population in 1900, 177; altitude, 7,566 feet.

Hoosac; gulch in Clear Creek County, tributary to Fall River. Idaho Springs Special.

Hoosier; pass in Park Range between Park and Summit counties.

Hoosier; ridge in Summit County..... Leadville.

Hoosier; station in Park County on Colorado and Southern Railway; altitude, 9,698 feet.

Hoosier Pass; station on Colorado and Cripple Creek District Railway; altitude, 10,309 feet..... Leadville.

Hope; mountain in Chaffee County.

Hope; mountain in La Plata County..... Needle Mountains.

Hope; village in Mesa County.

Hopkins; station in Eagle County on Colorado Midland Railway; altitude, 7,346 feet.

Horace; village in Teller County.

Horn; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Horn; peak in Sangre de Cristo Mountains Custer County; altitude, 13,447 feet.

Horse; canyon in Las Animas County, tributary to Purgatory River..... Higbee.

Horse; creek in Baca County, flowing east into Kansas and disappearing in a sink. Two Butte. Vilas. Albany.

Horse; creek in Eagle County, a right-hand branch of Grand River.

Horse; creek in Dolores County, a right-hand branch of East Dolores River..... Rico.

Horse; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Horse; creek in Montezuma County, a left-hand branch of Middle Rio Mancos..... La Plata.

Atlas sheet.

Horse; creek in Otero County, a left-hand branch of Arkansas River. — Sanborn. Catlin. Las Animas.

Horse; creek in Pueblo County, a right-hand branch of St. Charles River ..... Pueblo.

Horse; gulch in La Plata County, tributary to Animas River.. Durango

Horsefly; creek in Montrose County, a right-hand branch of San Miguel River, tributary to Dolores River.

Horsefly; peak in Montrose County; altitude, 10,504 feet.

Horsefly; village in Montrose County.

Horseshoe; gulch in Park County, tributary to Fourmile Creek ..... Leadville.

Horseshoe; mountain in Park Range, Lake County; altitude, 13,912 feet ..... Leadville.

Horseshoe; village in Park County on Colorado and Southern Railway; altitude, 10,598 feet ..... Leadville.

Horseshoe Basin; hanging valley in Hinsdale County..... Silverton.

Horsetail; creek in Logan County, a left-hand branch of South Platte River.

Hortense; post village in Chaffee County.

Horsethief; spring in Montrose County.

Hot; spring in Gunnison County..... Crested Butte.

Hot; springs in Ouray County; altitude, 7,086 feet ..... Ouray.

Hotchkiss; post town in Delta County; population in 1900, 261; altitude, 5,359 feet.

Hot Spring; creek in Mineral County, a right-hand branch of Rio Grande.

Hot Springs; station in Saguache County on Denver and Rio Grande Railroad; altitude, 7,757 feet.

Hot Sulphur; springs in Grand County.

Houghton; mountain in San Juan County..... Silverton

Hovenweep; creek in Montezuma County, a right-hand branch of San Juan River.

Howard; post village in Fremont County, on Denver and Rio Grande Railroad; altitude, 6,706 feet.

Howard; springs in San Miguel County.

Howard; springs in Weld County.

Howard Fork; in San Miguel County, a right-hand branch of Lake Fork San Miguel River ..... Telluride

Howard Fork; in Weld County, a right-nand branch of Crow Creek, tributary to South Platte River.

Howardsville; post village in San Juan County on Silverton Northern Railroad; altitude, 9,968 feet..... Silverton.

Howbert; post village in Park County on Colorado Midland Railway. Railroad and corporate name, Freshwater.

Howeville; town in Gunnison County.

Hudson; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Hudson; post village in Weld County on Burlington and Missouri River Railroad; altitude, 5,006 feet..... Greeley.

Huerfano; butte in Huerfano County; altitude, 6,150 feet.... Walsenburg.

Huerfano; county in the southern part of the State; bounded on the north by Custer and Pueblo counties, on the east

Atlas sheet.

Huerfano—Continued.
and south by Las Animas County, and on the west by Costilla and Saguache counties and Sangre de Cristo Range. The surface consists of rolling plains, with the exception of the western and a small portion of the northern boundaries. The area is 1,537 square miles, of which 3 per cent, or 25,466 acres, were under cultivation in 1900. The population in 1900 was 8,395; and of Walsenburg, the county seat, 1,033. In 1900 the average magnetic declination was 13° 00′ east. The mean annual rainfall is about 14 inches, and the mean annual temperature 45° to 50°.

Huerfano; lake in Pueblo County ..... Nepesta.

Huerfano; post village in Huerfano County on Denver and Rio Grande Railroad; altitude, 5,665 feet ..... Walsenburg.

Huerfano; river in Pueblo and Huerfano counties, a right-hand branch of Arkansas River. Walsenburg. Nepesta. Huerfano Park.

Huerfano Canyon; village in Huerfano County ..... Huerfano Park.

Huerfano Park; open valley sloping south between Wet Mountains and Sangre de Cristo Range.

Huerto; creek in Hinsdale County, a right-hand branch of Rio Piedra, tributary to San Juan River.

Hugo; county seat of Lincoln County on Union Pacific Railroad; altitude, 5,039 feet.

Hugo; hill in Lincoln County; altitude, 5,300 feet ..... Limon.

Hukill; gulch in Clear Creek County, tributary to Clear Creek. Idaho Springs Special.

Hulbert; station in El Paso County, on Denver and Rio Grande Railroad.

Hull; station in Teller County, on Florence and Cripple Creek Railroad.

Hulls Camp; village in Teller County ..... Cripple Creek Special.

Humbug; creek in Summit County, a right-hand branch of Tenmile River, tributary to Snake River. Tenmile District Special.

Humboldt; peak in Sangre de Cristo Mountains, Custer County; altitude, 14,044 feet.

Humphrey; station in Pitkin County on Colorado Midland Railway; altitude, 10,203 feet.

Hunchback; mountain in San Juan County; altitude, 13,133 feet ..... Needle Mountains.

Hungerfoot; lake in Pueblo County ..... Nepesta.

Hunt; creek in Rio Blanco and Routt counties, a left-hand branch of Yampa River.

Hunter; canyon in Las Animas County, tributary to Apishapa River ..... Spanish Peaks.

Hunter; creek in Pitkin County, a right-hand branch of Roaring Fork, tributary to Grand River ..... Aspen.

Hunter; hill in Gunnison County ..... Crested Butte.

Hunts; peak in Sangre de Cristo Mountains on boundary between Saguache and Fremont counties; altitude, 12,446 feet.

Atlas sheet.

Huntsmans; hills lying west of Elk Mountains, and extending northward to Grand River.

Hurricane; peak in San Juan Mountains, San Juan County; altitude, 13,565 feet..... Silverton.

Hurricane Basin; hanging valley in Hinsdale County..... Silverton.

Husted; post village in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 6,647 feet.

Hyatt; lake in Jefferson County..... Denver.

Hyde; station in Washington County on Burlington and Missouri River Railroad; altitude, 4,232 feet.

Hydraulic; village in Montrose County.

Hygiene; post village in Boulder County on Burlington and Missouri River Railroad; altitude, 5,086 feet..... Niwot.

Ibex; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,512 feet.

Ice; lake in San Juan County..... Telluride.

Ice Lake Basin; valley in San Juan County ..... Telluride.

Idaho; creek in Weld County, a right-hand branch of Boulder Creek ..... Niwot.

Idaho; gulch in San Juan County, tributary to Animas River. Silverton.

Idaho Creek; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,897 feet..... Niwot.

Idaho Springs; post town in Clear Creek County on Colorado and Southern Railway; population in 1900, 2,502; altitude, 7,556 feet. Idaho Springs Special.

Idalia; post village in Yuma County.

Idlewild; station in Park County on Colorado Midland Railway; altitude, 8,464 feet.

Ignacio; post village in La Plata County on Denver and Rio Grande Railroad; altitude, 6,425 feet.

Iles; mountain in Rio Blanco County.

Iliff; post village in Logan County on Union Pacific Railroad; altitude, 3,832 feet.

Ilium; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,108 feet..... Telluride.

Illinois; creek in Larimer County, a left-hand tributary of Michigan River.

Illinois; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special

Illinois; gulch in San Juan County, tributary to Cement Creek. Silverton.

Illinois; gulch in Summit County, tributary to Blue River.... Leadville.

Ilse; post village in Custer County.

Imogene Basin; valley in Ouray County..... Silverton.

Independence; creek in Larimer County, a left-hand branch of North Platte River.

Independence; gulch in Hinsdale County, tributary to Lake Fork Gunnison River..... Lake City.

Independence; post village in Teller County on Colorado Midland Railway..... Pikes Peak.

Independence; station in Arapahoe County on Golden Circle Railroad; altitude, 10,359 feet.

Independence Basin; valley in Gunnison County..... Anthracite.

Atlas sheet.

Indian; creek in Clear Creek County, a right-hand branch of Bear Creek, tributary to South Platte River ..... Georgetown.
Indian; creek in Douglas County, a left-hand branch of Plum Creek, tributary to South Platte River ..... Platte Canyon.
Indian; creek in Grand County, a left-hand branch of Frazer River, tributary to Grand River.
Indian; creek in Gunnison County, a right-hand branch of Gunnison River.
Indian; creek in Huerfano County, a left-hand branch of Middle Creek, tributary to Cuchara River..... Huerfano Park.
Indian; creek in Mesa County, a right-hand branch of Gunnison River.
Indian; gulch in Jefferson County, tributary to Clear Creek.. Blackhawk.
Indian; run in Rio Blanco and Routt counties, a right-hand branch of South Fork Williams River.
Indiana; creek in Summit County, a right-hand branch of Blue River, tributary to Grand River..... Leadville.
Indian Agency; in La Plata County, for the Southern Ute.
Indianapolis; village in Las Animas County ..... Mesa de Maya.
Indian Flat; valley in Clear Creek County..... Idaho Springs Special.
Indian Trail; ridge on boundary between La Plata and Montezuma counties. La Plata. Rico.
Ingram Basin; valley in San Miguel County..... Silverton.
Ingram; creek in San Miguel County, a right-hand branch of San Miguel River..... Telluride.
Ink; spring in Routt County; altitude, 6,012 feet.
Inman; station in Kiowa County on Missouri Pacific Railway; altitude, 4,347 feet..... Las Animas.
Insmont; post village in Park County.
Interlaken; village in Lake County ..... Leadville.
Iola; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,434 feet.
Ione; station in Weld County on Union Pacific Railroad; altitud, 4,862 feet.
Ionia; village in Mesa County.
Iowa; gulch in Lake County, tributary to Arkansas River.... Leadville.
Irelands; station in La Plata County on Denver and Rio Grande Railroad.
Iris; village in Saguache County.
Iron; canyon in Las Animas County, tributary to Purgatory River..... Timpas.
Iron; creek in Montrose County, a left-hand branch of Smith Fork.
Iron; hill in Lake County ..... Leadville.
Iron; mountain in Costilla and Huerfano counties ..... Huerfano Park.
Iron; mountain in Fremont County.
Iron; mountain in Gunnison County; altitude, 10,405 feet.
Iron; mountain in San Miguel County..... Telluride.
Iron; spring in San Miguel County..... Telluride.
Iron Clad; hill in Teller County..... Cripple Creek Special.

Atlas sheet.

Ironclads, The; summits in Boulder County; altitude, 9,100 feet ..... Boulder.
Irondale; station in Arapahoe County on Union Pacific Railroad; altitude, 5,115 feet.
Iron Springs; station in Otero County on Atchison, Topeka and Santa Fe Railway ..... Timpas.
Iron Springs; arroyo in Otero and Las Animas counties, a right-hand branch of Timpas Creek, tributary to Arkansas River ..... Timpas.
Ironton; post town in Ouray County on Silverton Railroad; population in 1900, 71 ..... Silverton.
Ironton Park, in Ouray County ..... Silverton.
Irrawaddy; creek in Garfield County, a right-hand branch of Grand River.
Irving; peak in San Juan Mountains, La Plata County; altitude, 13,210 feet ..... Needle Mountains.
Irwin; town in Gunnison County; population in 1900, 26 ..... Anthracite.
Isabella; station in Teller County on Florence and Cripple Creek Railroad.
Island; lake in San Juan County ..... Telluride.
Island; mesa in San Miguel County.
Italian; creek in Gunnison County, a right-hand branch of Taylor River, tributary to Gunnison River.
Italian; mountain in Elk Mountains; altitude, 13,350 feet.
Ivanhoe; post village in Pitkin County on Colorado Midland Railway; altitude, 10,927 feet.
Jack; canyon in Otero County tributary to Purgatory River.
Jack; creek in Larimer County, a right-hand branch of Illinois Creek, tributary to North Platte River.
Jackass; creek in Garfield County, a right-hand branch of Grand River.
Jackass Basin; valley in San Miguel County ..... Telluride.
Jacks Cabin; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,298 feet.
Jackson; butte in Montezuma County; altitude, 5,326 feet.
Jackson; creek in Douglas County, a left-hand branch of Plum Creek, tributary to South Platte River ..... Platte Canyon.
Jackson; mountain in Eagle County.
Jackson; ridge in Montezuma County ..... La Plata.
Jackson: village in Gunnison County; altitude, 9,036 feet .... Ouray.
Jacona; station on Denver and Rio Grande Railroad; altitude, 6,270 feet.
Jacque; creek in Summit County, a left-hand branch of Tenmile Creek, tributary to Snake River ..... Leadville.
Jacque; gulch in Summit County, tributary to West Fork Tenmile River. ..... Tenmile District Special.
Jacque; peak in Summit County; altitude, 13,215 feet ..... Leadville.
Jacque; ridge in Summit County ..... Tenmile District Special.
Jagged; mountain in San Juan Mountains, San Juan County; altitude, 13,829 feet ..... Needle Mountains.
James; peak in Front Range, on boundary between Gilpin, Grand, and Clear Creek counties; altitude, 13,283 feet.

Atlas sheet.

Jamestown; village in Boulder County; population in 1900, 164; altitude, 6,920 feet..... Boulder.

Janeway; village in Pitkin County on Crystal River Railroad; altitude, 6,697 feet.

Jansen; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 6,166 feet.

Jarosa; canyon in Las Animas County, through which flows a left-hand branch of Apishapa River..... Spanish Peaks.

Jarre; creek in Douglas County, a left-hand branch of Plum Creek, tributary to South Platte River..... Platte Canyon.

Jason; station in Lake County on Denver and Rio Grande Railroad.

Jasper; village in Rio Grande County.

Jay; creek in Delta County, a right-hand branch of North Fork Gunnison River.

Jay; village in Ouray County.

Jefferson; county in the central part of the State; bounded on the north by Boulder County, on the east by Adams, Arapahoe, and Douglas counties, on the south by Douglas and Park counties, and on the west by Park, Clear Creek, and Gilpin counties. It lies mostly in the foothills of Front Range, including in the northeast a small area of high rolling plain. The area is 840 square miles, of which 11 per cent, or 61,224 acres, were under cultivation in 1900. The population in 1900 was 9,306, and of Golden, the county seat, 2,152. In 1900 the average magnetic declination was 13° 25′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 45° to 50°.

Jefferson; creek in Park County, a left-hand branch of Tarryall Creek.

Jefferson; post village in Park County on Colorado and Southern Railway; altitude, 9,500 feet.

Jefferson; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Jenks; gulch in Boulder County, tributary to Jim Creek..... Boulder.

Jenny Branch; in Las Animas and Bent counties, a right-hand branch of Muddy Creek, tributary to Arkansas River..... Higbee.

Jerome; peak in Pitkin County.

Jim; creek in Boulder County, a right-hand branch of Left-hand Creek, tributary to South St. Vrain Creek..... Boulder.

Jim; creek in Saguache County, a left-hand branch of Saguache River.

Jimmy; creek, in Larimer County, a right-hand branch of Laramie River.

Jimmy Camp; creek in El Paso County, a left-hand branch of Fountain Creek, tributary to Arkansas River..... Colorado Springs.

Jimmy Camp; station in El Paso County on a spur of Colorado and Southern Railway..... Colorado Springs.

Jimtown; village in Mineral County.

John; lake in Larimer County.

Johnny Bull; creek in Dolores County, a left-hand branch of Dolores River..... Rico.

Atlas sheet.

Johnny Bull; mountain in San Juan Mountains, Dolores County; altitude, 12,018 feet ..... Rico.
Johnson; creek in La Plata County, a left-hand branch of Florida River ..... Needle Mountains.
Johnson; ford across Uncompahgre River; altitude, 5,702 feet.
Johnson; station in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 6,169 feet.
Johnson; town in Jefferson County.
Johnsons; station in Summit County on Colorado and Southern Railway.
Johnstown; post village in Weld County.
Jones; mountain on boundary between Hinsdale and San Juan counties; altitude, 13,851 feet ..... Silverton.
Jones; pass in Front Range, between Clear Creek and Grand counties.
Jordan; creek in Rio Blanco County, a right-hand branch of White River.
Joy; station in Pueblo County on Denver and Rio Grande Railroad.
Juanita; post village in Archuleta County on Denver and Rio Grande Railroad; altitude, 6,329 feet.
Jubb; creek in Routt County, a left-hand branch of Yampa River.
Julesburg; post town and county seat of Sedgwick County on Union Pacific Railroad; population in 1900, 371; altitude, 3,468 feet.
Julien; station in Logan County on Burlington and Missouri River Railroad.
Jumping; creek in Eagle County, a right-hand branch of Weary Mans Creek, tributary to Eagle River.
Junction; butte in Grand County; altitude, 8,266 feet.
Junction; creek in La Plata County, a right-hand branch of Animas River ..... Durango.
Junction; mountain in Routt County; altitude, 7,868 feet.
Junction; plateau in Routt County.
Junction; station in Boulder County on Colorado and Southern Railway.
Jupiter; peak in San Juan Mountains, La Plata County; altitude, 13,830 feet ..... Needle Mountains.
Justice; hill in Gilpin County; altitude, 8,722 feet ..... Blackhawk.
Kahnah; creek in Mesa County, a right-hand branch of Gunnison River.
Kahnah; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,673 feet.
Kalbaugh; town in Fremont County.
Kanes; station in San Juan County on Denver and Rio Grande Railroad.
Katchout; station in Gunnison County on Colorado and Southern Railway.
Kearney; station in Denver County on Denver and Rio Grande Railroad.
Kebler Pass; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 9,946 feet.

Atlas sheet.

Keeldar; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,959 feet.

Keene; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 9,291 feet.

Keene; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,970 feet ..... Greeley.

Kelker; station in El Paso County on Denver and Rio Grande Railroad; altitude, 5,835 feet..... Colorado Springs.

Kelloggs; station in Gunnison County on Denver and Rio Grande Railroad ..... Lake City.

Kelly; lake in Jefferson County ..... Denver.

Kelly; spring in Pueblo County ..... Pueblo.

Kelso, Mount; in Summit County.

Kendall; gulch in San Juan County, tributary to Animas River..... Silverton.

Kendall; peak in San Juan Mountains, San Juan County; altitude, 13,480 feet..... Silverton.

Kennedy; gulch in Costilla County, tributary to Placer Creek. Huerfano Park.

Kenosha; mountains, a spur of Front Range, separating the branches of South Platte River.

Kenosha; station in Park County on Colorado and Southern Railway; altitude, 9,983 feet.

Kenosha Twin Cones; in Kenosha Mountains, in the northern part of South Park. Altitudes—west, 12,340 feet; east, 12,350 feet.

Kenwood; station in Arapahoe County on Colorado and Southern Railway; altitude, 5,534 feet..... Denver.

Keota; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,966 feet.

Kepner; station in Las Animas County on Colorado and Southern Railway. Post-office, Rugby.

Kerber; creek, a left-hand branch of San Luis Creek.

Kerr; station in Fremont County on Denver and Rio Grande Railroad.

Kersey; post village in Weld County on Union Pacific Railroad; altitude, 4,612 feet..... Greeley.

Kester; village in Park County.

Kettle; creek in El Paso County, a left-hand branch of Beaver Creek, tributary to Arkansas River..... Castle Rock.

Keyes, Mount; in Sawatch Range; altitude, 13,750 feet.

Keystone; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 6,646 feet..... Telluride.

Keystone; station in Summit County on Denver and Rio Grande Railroad; altitude, 9,161 feet.

Kezar; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,414 feet.

Kilburn; station in Kiowa County on Missouri Pacific Railway; altitude, 4,305 feet ..... Las Animas.

Kilburn; village in Larimer County.

Kilpacker; creek in Dolores County, a right-hand branch of East Dolores River, tributary to Dolores River..... Telluride.

Kilton; station in Fremont County on Denver and Rio Grande Railroad.

Atlas sheet.

Kimball; creek in Mesa County, a right-hand branch of Plateau River.

Kimbrell; village in Saguache County.

Kimmerman; lake in Larimer County.

Kincaid; station in Huerfano County on Denver and Rio Grande Railroad.

King; station in Douglas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,995 feet.

King; village in Park County on Denver and Rio Grande Railroad; altitude, 8,173 feet.

King Center; station in Otero County on Missouri Pacific Railway.

King Reservoir; artificial lake in Kiowa County; altitude, 3,860 feet ..... Lamar.

Kings; station in Montezuma County on Denver and Rio Grande Railroad.

Kings Flat; valley in Gilpin County ..... Central City Special.

King Solomon; gulch in Clear Creek County, tributary to Chicago Creek ..... Georgetown.

King Solomon; mountain in San Juan Mountains, San Juan County ..... Silverton.

Kiowa; county in the eastern part of the State; bounded on the north by Cheyenne County, on the east by Kansas, on the south by Bent and Prowers counties, and on the west by Otero and Lincoln counties. It consists of rolling plains and is traversed east and west by the Missouri Pacific Railway. The area is 1,780 square miles, of which less than one-half of 1 per cent, or 4,138 acres, were under cultivation in 1900. The population in 1900 was 701, and of Sheridan Lake, the county seat, 100. In 1900 the average magnetic declination was 12° 00′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Kiowa; creek in Elbert, Arapahoe, Morgan, and Weld counties, a right-hand branch of South Platte River. Castle Rock. Denver.

Kiowa; post village and county seat of Elbert County.

Kiowa; springs in Kiowa County ..... Lamar

Kirk; post village in Yuma County.

Kit Carson; county in the extreme eastern part of the State; bounded on the north by Washington and Yuma counties, on the east by Kansas, on the south by Cheyenne County, and on the west by Lincoln County. It consists of rolling plains and is traversed east and west by the Union Pacific Railroad. The area is 2,168 square miles, of which less than 2 per cent, or 19,581 acres, were under cultivation in 1900. The population in 1900 was 1,580 and of Burlington, the county seat, 183. In 1900 the average magnetic declination was 12° 35′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Kit Carson; peak in Sangre de Cristo Range on boundary between Custer and Saguache counties; altitude, 14,100 feet.

Atlas sheet.

Kit Carson; post village in Cheyenne County on Union Pacific Railroad; altitude, 4,284 feet ..... Kit Carson.

Kline; post village in La Plata County.

Klink; station in Adams County on Burlington and Missouri River Railroad.

Knob; mountain in Teller County; altitude, 10,235 feet ..... Cripple Creek Special.

Knowltons; station in Gunnison County on Denver and Rio Grande Railroad.

Kobe; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,147 feet.

Koen; station in Prowers County on Atchison, Topeka and Santa Fe Railway; altitude, 3,507 feet.

Koen; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,870 feet.

Kokomo; gulch in Summit County, tributary to Tenmile Creek. Tenmile District Special.

Kokomo; post village in Summit County on Colorado and Southern Railway; altitude, 10,652 feet ..... Leadville.

Konantz; post village in Baca County.

Kramer; creek in Pueblo County, a left-hand branch of Arkansas River ..... Nepesta.

Kremmling; post village in Grand County.

Kuhns Crossing; post village in Elbert County.

Kutch; post village in Lincoln County.

La Boca; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,165 feet.

Lacy; station in Garfield County on Colorado Midland Railway.

Ladd; creek in Routt County, a left-hand branch of Bear River, tributary to Yampa River.

Ladder; creek in Cheyenne County, a right-hand branch of Smoky Hill River ..... Cheyenne Wells.

Ladore; post village in Routt County.

Lafayette; post town in Boulder County, on the Colorado and Southern and the Burlington and Missouri River railroads; population in 1900, 970; altitude, 5,094 feet ..... Denver.

La Garita; creek in Saguache County, flowing into a sink.

La Garita; hills in San Juan Mountains, rising from the western edge of San Luis Valley, just north of Rio Grande.

La Garita; post village in Saguache County on Denver and Rio Grande Railroad; altitude, 7,551 feet.

Laird; post village in Yuma County on Burlington and Missouri River Railroad; altitude, 3,404 feet.

La Jara; creek, a right-hand branch of Rio Grande.

La Jara; post town in Conejos County on Denver and Rio Grande Railroad; population in 1900, 208; altitude, 7,597 feet.

La Junta; county seat of Otero County on Atchison, Topeka and Santa Fe Railway; population in 1900, 2,513; altitude, 4,052 feet ..... Timpas.

La Junta; peak in San Miguel County ..... Telluride.

La Junta Basin; valley in San Miguel County ..... Telluride.

Atlas sheet.

Lake; county near the center of the State; bounded on the north by Eagle and Summit counties, on the east by Park County, on the south by Chaffee County, and on the west by Pitkin County. It includes the upper valley of Arkansas River, and extends from the summit of Park Range to that of Sawatch Range. The area is 393 square miles, of which 3 per cent, or 7,636 acres, were under cultivation in 1900. The population in 1900 was 18,054; and of Leadville, the county seat, 12,455. In 1900 the magnetic declination was 14° 20′ east. The mean annual rainfall is about 14 inches, and the mean annual temperature 40° to 45°.

Lake; creek in Lake County, inlet to Twin Lakes ..... Leadville.

Lake; gulch in Gilpin County, tributary to North Clear Creek. Central City Special.

Lake; mesa in Boulder County ..... Denver.

Lake; station in Lincoln County on Union Pacific Railroad; altitude, 5,299 feet.

Lake City; post town and county seat of Hinsdale County on Denver and Rio Grande Railroad; population in 1900, 700; altitude, 8,675 feet ..... Lake City.

Lake City; village in Pitkin County.

Lake Creek; pass between Lake and Gunnison counties; altitude, 12,226 feet.

Lake Fork; in Gilpin County, a left-hand branch of North Clear Creek, tributary to Clear Creek ..... Blackhawk.

Lake Fork; in Lake County, a right-hand branch of Arkansas River, heading in North and South forks ..... Leadville.

Lake Fork; in Park County, a left-hand branch of East Geneva Creek, tributary to South Platte River ..... Georgetown.

Lake Fork; mountains in Hinsdale County; altitude, 13,722 feet.

Lake Fork; station in Lake County on Colorado Midland Railway.

Lake Fork Gunnison; river in Gunnison County, a left-hand branch of Gunnison River ..... Lake City.

Lake Fork San Miguel; river in San Miguel County, a left-hand branch of San Miguel River ..... Telluride.

Lake George; station in Park County on Colorado Midland Railway; altitude, 7,963 feet ..... Pikes Peak.

Lake Hughes; town in Ouray County.

Lake Junction; station in Gunnison County on Denver and Rio Grande Railroad; altitude 7,225 feet.

Lake Junction; station in Boulder County on Colorado and Southern Railway.

Lake Shore; village in Hinsdale County; altitude, 9,158 feet.. San Cristobal.

Lakewood; station in Jefferson County on Denver, Lakewood and Golden Railroad.

Lamar; town and county seat of Prowers County on Atchison, Topeka and Santa Fe Railway; population in 1900, 987; altitude, 3,610 feet ..... Lamar.

Lamartine; village in Clear Creek County; altitude, 10,620 feet ..... Georgetown.

Lamb; post village in Jefferson County.

Lamb; mountain in Park County ..... Leadville.

Atlas sheet.

Lamborn; station in Kit Carson County, on Chicago, Rock Island and Pacific Railway.

Lamborn, Mount; in Elk Mountains, Montrose County; altitude, 11,337 feet.

Lanark; village in Saguache County.

Landsend; peak in Elk Mountains, Montrose County; altitude, 10,634 feet.

Landslide; mountain in Grand County.

Landslip; mountain in Dolores County ..... Rico.

Landsman; hill in Cheyenne County; altitude, 4,642 feet .... Kit Carson.

Landsman; post village in Yuma County.

Langdell; station in Boulder County on Colorado and Northwestern Railroad.

Langford; station in Boulder County on Colorado and Southern Railway.

Lannons; station in Pueblo County on Denver and Rio Grande Railroad.

Lansing; post village in Yuma County.

Lapis; station in Chaffee County on Denver and Rio Grande Railroad.

La Plata; county in the southwestern part of the State; bounded on the north by San Juan County, on the east by Hinsdale and Archuleta counties, on the south by New Mexico, and on the west by Montezuma County. The northern part of the county is mountainous, consisting of a part of San Juan Mountains. The remainder is made up of long spurs from these mountains extending southward. The area is 1,848 square miles, of which 1 per cent, or 14,491 acres, were under cultivation in 1900. The population in 1900 was 7,016; and of Durango, the county seat, 3,317. In 1900 the average magnetic declination was 13° 30′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 50° to 55°.

La Plata; mountains forming the southwestern part of San Juan Mountains, in the southwestern part of the State.... La Plata.

La Plata; peak in Sawatch Range, Chaffee County; altitude, 14,342 feet..... Leadville.

La Plata; post village in La Plata County..... La Plata.

La Plata; river in Colorado and New Mexico, a branch of San Juan River, heading in La Plata Mountains, and flowing southward to its mouth near Farmington, New Mex..... La Plata.

La Plata Junction; station in La Plata County on Denver and Rio Grande Railroad.

La Porte; post village in Larimer County; altitude, 5,069 feet.

Laramie; lake in Larimer County.

Laramie; river in Larimer County, a right-hand branch of North Platte River, heading in Front Range and flowing north and then northeast into Wyoming.

Larimer; county in the extreme northern part of the State; bounded on the north by Wyoming, on the east by Weld County, on the south by Grand and Boulder counties, and on the west by the summit of Park Range. The eastern part consists of rolling plains, while the central part is trav-

Atlas sheet.

Larimer—Continued.
ersed by Front and Medicine Bow ranges. The western portion comprises North Park, an elevated tract of rolling plain. The area is 4,337 square miles, of which 7 per cent, or 180,353 acres, were under cultivation in 1900. The population in 1900 was 12,168; and of Fort Collins, the county seat, 3,053. In 1900 the average magnetic declination was 13° 25′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 40° to 45°.

Larimer; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 5,780 feet.

Larkspur; butte in Douglas County..... Castle Rock.

Larkspur; station in Douglas County, on the Atchison, Topeka, and Santa Fe and the Denver and Rio Grande railroads; altitude, 6,657 feet..... Castle Rock.

Larson; creek in Hinsdale County, a left-hand branch of Lake Fork Gunnison River..... Lake City.

Lasalle; post village in Weld County on Union Pacific Railroad; altitude, 4,676 feet..... Greeley.

Las Animas; county in the southern part of the State; bounded on the north by Pueblo, Otero, and Bent counties, on the east by Baca County, on the south by New Mexico, and on the west by Huerfano and Costilla counties. Its surface consists of rolling plains sparsely settled in the western part, but more thickly populated in the eastern portion, where the Atchison, Topeka and Santa Fe, the Colorado and Southern, and the Denver and Rio Grande railroads have promoted development. The area is 4,802 square miles, of which 1 per cent, or 38,441 acres, were under cultivation in 1900. The population in 1900 was 21,842; and of Trinidad, the county seat, 5,345. In 1900 the average magnetic declination was 12° 00′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Las Animas; post town and county seat of Bent County on Atchison, Topeka and Santa Fe Railway; population in 1900, 1,192; altitude, 3,884 feet..... Las Animas.

Las Animas; river in Las Animas County, a left-hand branch of Purgatory River.

Lasauses; post village in Conejos County.

Las Pinos; creek in Rio Grande County, a right-hand branch of Rio Grande.

Last Chip Junction; station on Denver and Rio Grande Railroad; altitude, 10,301 feet.

Last Dollar; station in Teller County, on the Colorado Springs and Cripple Creek District and the Florence and Cripple Creek railroads.

Last Resort; creek in Jefferson County, a left-hand branch of North Fork South Platte River..... Platte Canyon.

Laurium; village in Summit County.

Lavalley; post village in Costilla County.

Lavender; post village in Dolores County.

Atlas sheet.

Laveta; pass on boundary between Costilla and Huerfano counties.

Laveta; peak in Sangre de Cristo Range, Huerfano County; altitude, 11,000 feet ..... Huerfano Park.

Laveta; post town in Huerfano County on Denver and Rio Grande Railroad; population in 1900, 254; altitude, 7,012 feet.

Laveta Pass; post village in Costilla County.

Lawrence; town in Teller County; population in 1900, 299... Pikes Peak.

Lawson; post village in Clear Creek County on Colorado and Southern Railway; altitude, 8,126 feet.

Lay; creek in Routt County, a right-hand branch of Yampa River.

Lay; post village in Routt County; altitude, 6,200 feet.

Laya; station in Conejos County on Denver and Rio Grande Railroad; altitude, 8,468 feet.

Leadville; county seat of Lake County, on the Denver and Rio Grande, the Colorado and Southern, and the Colorado Midland railways; an important mining and smelting center; population in 1900, 12,455; altitude, 10,190 feet..... Leadville.

Leadville Forest Reserve; area 1,906 square miles.

Leadville Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,747 feet.

Leal; post village in Grand County.

Leander; station in El Paso County on Denver and Rio Grande Railroad.

Leavenworth; creek in Clear Creek County, a left-hand branch of South Clear Creek, tributary to Clear Creek .... Georgetown.

Leavenworth; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special.

Leavenworth; gulch in La Plata County, tributary to Flagler Fork ..... Durango.

Leavenworth; mountain in Clear Creek County; altitude, 10,390 feet ..... Georgetown.

Leavick; station in Park County on Colorado and Southern Railway.

Leeds; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,728 feet.

Lee Hill; village in Boulder County; altitude, 7,518 feet..... Boulder.

Lees; village in Pueblo County.

Lefthand; creek in Boulder County, a right-hand branch of St. Vrain Creek, tributary to South Platte River. Niwot. Boulder.

Lehman; post town in Grand County.

Lena Basin; valley in San Miguel County..... Telluride.

Lenado; post village in Pitkin County.

Lenore; lake in Ouray County..... Ouray.

Lenox; creek in Mesa County, a right-hand branch of Plateau River.

Leon; peak on plateau in Mesa County; altitude, 10,954 feet.

Leon; station in Garfield County on Denver and Rio Grande Railroad; altitude, 6,427 feet.

Leon Park; valley in Mesa County.

Atlas sheet.

Leonard; post village in San Miguel County.
Leopard Creek; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,598 feet.
Leroux; creek in Delta County, a right-hand branch of Gunnison River.
Le Roy; post village in Logan County; altitude, 4,380 feet.
Leshers; station on Colorado and Southern Railway; altitude, 5,333 feet.
Leslie; gulch in San Miguel County, tributary to East Dolores River ..... Telluride.
Leslie; village in Washington County.
Leviathan; peak in San Juan Mountains, San Juan County; altitude, 13,528 feet ..... Needle Mountains.
Lewis; creek in La Plata County, a left-hand branch of La Plata River ..... La Plata.
Lewis; creek in Logan County, a left-hand branch of South Platte River.
Lewis; mountain in La Plata County ..... La Plata.
Leyden; gulch in Jefferson County, tributary to Ralston Creek ..... Denver.
Liberty; post village in Saguache County. Railroad name, Cottonwood.
Liberty Hall; village in Weld County ..... Niwot.
Lida Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,102 feet.
Lidderdale; station in Jefferson County on Colorado Midland Railway; altitude, 8,071 feet.
Lightner; creek in La Plata County, a right-hand branch of Animas River, originating in South Fork. Durango. La Plata.
Lilie; mountain in Front Range, Larimer County; altitude, 11,433 feet.
Lillie; lake in La Plata County ..... Needle Mountains.
Lillie; station in Teller County on Florence and Cripple Creek Railroad; altitude, 10,218 feet.
Lillie Junction; station on Golden Circle Railroad; altitude, 10,244 feet.
Lilly; gulch in Jefferson County, tributary to South Platte River ..... Denver.
Lily; post village in Routt County.
Lilys Park; valley in Routt County, north of Yampa River and east of Snake River.
Lime; creek in San Juan and La Plata counties, a right-hand branch of Animas River ..... Needle Mountains.
Lime; creek in Eagle and Pitkin counties, a right-hand branch of Frying Pan Creek, tributary to Roaring Fork.
Lime; mesa in La Plata County ..... Needle Mountains.
Lime; post town in Pueblo County. Railroad name, Sonora.
Lime; station in San Miguel County on Denver and Rio Grande Railroad.
Lime Creek; station in Pitkin County on Colorado Midland Railway; altitude, 8,060 feet.
Limestone; butte in Logan County.

	Atlas sheet.
Limestone; canyon in Garfield County, tributary to South Fork White River.	
Limestone; creek in Bent County, a left-hand branch of Arkansas River	Lamar.
Limon; post village in Lincoln County, on the Union Pacific, and the Chicago, Rock Island and Pacific railways; altitude, 5,360 feet	Limon.
Lincoln; county in the eastern part of the State; bounded on the north by Washington County, on the east by Kit Carson, Cheyenne, and Kiowa counties, on the south by Kiowa and Otero counties, and on the west by Elbert and El Paso counties. It consists of rolling plains, and is traversed by the Union Pacific and the Chicago, Rock Island and Pacific railroads. The area of the county is 2,553 square miles, of which one-half of 1 per cent, or 8,195 acres, were under cultivation in 1900. The population in 1900 was 926; and of Hugo, the county seat, 120. In 1900 the average magnetic declination was 12° 45′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 50° to 55°.	
Lincoln; lake in Clear Creek County; altitude, 11,860 feet	Georgetown.
Lincoln, Mount; in Park Range, on boundary between Summit and Park counties; altitude, 14,297 feet	Leadville.
Lindon; post village in Washington County.	
Linton; station in Saguache County, on Denver and Rio Grande Railroad.	
Little Bear; creek in Clear Creek County, a right-hand branch of Clear Creek	Georgetown.
Little Bear; creek in Routt County, a left-hand branch of Fortification Creek, tributary to Bear River.	
Little Beaver; creek in Rio Blanco County, a right-hand branch of White River.	
Little Blue; creek in Gunnison County, a left-hand branch of Gunnison River	Lake City.
Little Book; cliffs in Garfield and Rio Blanco counties.	
Little Buttes; station in El Paso County on Denver and Rio Grande Railroad; altitude, 5,345 feet	Colorado Springs.
Little Cimarron; creek in Gunnison County, a left-hand branch of Gunnison River	Lake City.
Little Cottonwood; creek in Freemont County, a right-hand branch of Arkansas River.	
Little Cottonwood; creek in Montrose County, a right-hand branch of San Miguel River.	
Little Crow; creek in Weld County, a right-hand branch of Crow Creek, tributary to South Platte River.	
Littledale; station in Park County on Colorado Midland Railway	Pikes Peak
Little Deadwood; gulch in La Plata County, a left-hand branch of La Plata River	La Plata.
Little Dolores; creek in Mesa County, a left-hand branch of Grand River.	
Little Dry; creek in Arapahoe County, a right-hand branch of *South Platte* River	Denver.

Atlas sheet.

Little Elk; creek in Gunnison and Hinsdale counties, a left-hand branch of Elk Creek, tributary to Lake Fork Gunnison River ..... Lake City.
Little Evans; gulch in Lake County, tributary to East Fork Arkansas River ..... Leadville.
Little Fountain; creek in El Paso County, a right-hand branch of Fountain Creek, tributary to Arkansas River ..... Colorado Springs.
Little Giant; mountain in San Juan County ..... Silverton.
Little Giant Basin; valley in San Juan County ..... Silverton.
Little Grizzly; creek in Larimer County, a left-hand branch of North Platte River.
Little Horse; creek in Lincoln County, a left-hand branch of Horse Creek, tributary to Arkansas River ..... Sanborn.
Little Idaho; creek in Weld County, a right-hand branch of St. Vrain Creek, tributary to South Platte River ..... Greeley.
Little Jim; creek in Boulder County, a left-hand branch of Jim Creek, tributary to Lefthand Creek ..... Boulder.
Little Lone Cone; summit in San Miguel County; altitude, 12,001 feet.
Little Pisgah; peak in Teller County; altitude, 9,822 feet.... Pikes Peak.
Little Sacramento; gulch in Park County, tributary to South Platte River ..... Leadville.
Little Scraggy; peak in Jefferson County; altitude, 9,640 feet. Platte Canyon.
Little Sheep; mountain in Huerfano County; altitude, 9,600 feet ..... Huerfano Park.
Little Silver Basin; valley in Gunnison County ..... Anthracite.
Little Snake; river in Routt County, a right-hand branch of Yampa River.
Little Texas; creek in Fremont County, a left-hand branch of Texas Creek, tributary to Arkansas River.
Little Thompson; creek in Weld County, a right-hand branch of Thompson Creek, tributary to South Platte River, heading in South Branch ..... Greeley.
Littleton; post town and county seat of Arapahoe County on Atchison, Topeka and Santa Fe Railway; population in 1900, 738; altitude, 5,358 feet.
Little Union; gulch in Lake County, tributary to Arkansas River ..... Leadville.
Little Ute; creek in Costilla County, a right-hand branch of Ute Creek, tributary to Trinchera River ..... Huerfano Park.
Little West; creek in Teller County, a left-hand branch of West Creek, tributary to South Platte River ..... Platte Canyon.
Little Winnie; station on Denver and Rio Grande Railroad; altitude, 11,168 feet.
Livermore; post village in Larimer County.
Livesey; station in Pueblo County on the Atchison, Topeka and Santa Fe and the Denver and Rio Grande railroads; altitude, 4,783 feet.
Living Spring; village in Adams County.
Lizard Head; summit in San Juan Mountains, San Miguel County; altitude, 13,156 feet ..... Telluride.
Lizard Head; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 10,238 feet.

Atlas sheet.

Lobatos; post town in Conejos County.

Lockett; post village in Saguache County.

Loco; post town in Kit Carson County,

Lodge; lake in Pueblo County ..... Nepesta.

Lodi; station in Morgan County, on Burlington and Missouri River Railroad.

Lodore; canyon in Routt County, through which Green River flows.

Logan; county in the extreme northern part of the State; bounded on the north by Nebraska, on the east by Sedgwick and Phillips counties, on the south by Washington County, and on the west by Weld County. It consists of rolling plains, and is traversed by South Platte River, and by the Union Pacific and the Burlington and Missouri River railroads. Its area is 1,733 square miles, of which 5 per cent, or 57,639 acres were under cultivation in 1900. The population in 1900 was 3,292; and of Sterling, the county seat, 998. In 1900 the average magnetic declination was 13° 20′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Logan; hill in Boulder County; altitude, 7,700 feet ..... Boulder.

Logan; village in Arapahoe County.

Logcabin; post town in Larimer County.

Logtown; village in La Plata County ..... Needle Mountains.

Lolita; station in Otero County on Missouri Pacific Railway; altitude, 4,299 feet ..... Catlin.

Loma; post town in Mesa County on Denver and Rio Grande Railroad; altitude, 4,515 feet.

Loma; town in Huerfano County.

Loma Junction; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 6,204 feet. Post-office, Walsen.

London; hill in Park County ..... Leadville.

London Junction; station in Park County on Denver and Inter-Mountain Railway ..... Leadville.

Lone; mesa in Dolores County.

Lone; peak in Summit County; altitude, 11,300 feet.

Lone Cone; summit in San Juan Mountains, Dolores and San Miguel counties; altitude, 12,761 feet.

Lone Dome; post village in Montezuma County.

Lone Jack; canyon in Pueblo and Huerfano counties, tributary to Mustang Creek ..... Apishapa.

Lone Tree; arroyo in Otero and Las Animas counties, a right-hand branch of Timpas Creek, tributary to Arkansas River.. Timpas.

Lone Tree; creek in Weld County, a left-hand branch of South Platte River ..... Greeley.

Lonetree; station in Gilpin County on Colorado and Southern Railway ..... Blackhawk.

Long; canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.

Long; gulch in Boulder County, tributary to North St. Vrain Creek ..... Boulder.

Long and Derry; hill in Lake County near Leadville..... Leadville.

Atlas sheet.

Long Branch; in Lincoln County, a left-hand branch of Rush Creek, tributary to Arkansas River. Limon. Sanborn. Arroyo.

Longfellow; station in Chaffee County on Denver and Rio Grande Railroad.

Long Hungry; gulch in Teller County, tributary to Oil Creek. Pikes Peak.

Long Junction; station on Colorado and Southern Railway; altitude, 6,194 feet.

Longmeadow; station in Park County on Colorado and Southern Railway; altitude, 8,233 feet.

Longmont; post town in Boulder County, on the Burlington and Missouri River and the Colorado and Southern railways; population in 1900, 2,201; altitude, 4,941 feet..... Niwot.

Longs; canyon in Las Animas County, tributary to Cimarron River; altitude, 8,402 feet..... Mesa de Maya.

Longs; creek in southern Colorado and New Mexico, a right-hand branch of Purgatory River.

Longs; mesa in Las Animas County, south of Mesa de Maya; altitude, 6,210 feet..... Mesa de Maya.

Longs; peak in Front Range, Boulder County; altitude, 14,271 feet.

Longs Canyon Junction; station in Las Animas County on Denver and Rio Grande Railroad.

Long Scraggy; peak in Jefferson County; altitude, 8,210 feet. Platte Canyon.

Lookout; mountain in Fremont County.

Lookout; peak in San Juan Mountains, San Miguel County; altitude, 13,674 feet..... Telluride.

Loop; station in Teller County on Florence and Cripple Creek Railroad; altitude, 9,113 feet.

Lords; station on Colorado and Southern Railway; altitude, 5,352 feet.

Lorencito; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.

Lorencito; station in Las Animas County on Colorado and Wyoming Railway; altitude, 6,724 feet.

Loretto; post village in Arapahoe County.

Los Angelos; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Los Brazos; village in Conejos County.

Los Cerritos; post village in Conejos County.

Los Piños; creek in Saguache County, a left-hand branch of Cochetopa Creek, tributary to Tomichi Creek.

Los Piños; station in Conejos County on Denver and Rio Grande Railroad; altitude, 9,625 feet.

Los Piños; village in La Plata County; altitude, 6,680 feet.

Los San Jose; village in Conejos County.

Lost; canyon in Lake and Chaffee counties, tributary to Twin Lakes..... Leadville.

Lost; canyon in Montezuma County, tributary to Dolores River. Rico.

Lost; creek in Clear Creek County, a right-hand branch of Bear Creek, tributary to South Platte River..... Georgetown.

Lost Cañon; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 6,943 feet.

Atlas sheet.

Lostman; gulch in Kit Carson and Arapahoe counties, tributary to South Fork Republican River.

Lost Park; creek in Park and Jefferson counties, a right-hand branch of South Platte River.

Lost Park; mountain in Park County; altitude, 11,800 feet.

Lost Park; village in Park County.

Lost Trail; creek in Hinsdale County, a left-hand branch of Rio Grande ..... San Cristobal.

Lost Trail; village in Hinsdale County; altitude, 9,538 feet.

Lotus; station in Ouray County on Denver and Rio Grande Railroad.

Louisville; post town in Boulder County on Colorado and Southern Railway; population in 1900, 906; altitude, 5,332 feet..... Denver.

Louisville Junction; station in Boulder County on Colorado and Southern Railway; altitude, 5,340 feet.

Love; station in Teller County on Colorado Springs and Cripple Creek District Railway; altitude, 9,690 feet.

Loveland; pass between Summit and Clear Creek counties; altitude, 11,876 feet.

Loveland; post village in Larimer County on Colorado and Southern Railway; population in 1900, 1,091; altitude, 4,986 feet.

Low; creek in Ouray County, a right-hand branch of Cow Creek, tributary to Uncompahgre River..... Ouray.

Lower Beaver Park; valley in Teller County..... Pikes Peak.

Lower Muddy; butte in Grand County; altitude, 9,370 feet.

Lower Park; valley in La Plata County..... Needle Mountains.

Lowland; station in Elbert County on Union Pacific Railroad; altitude, 5,316 feet.

Lucerne, post village in Weld County on Union Pacific Railroad; altitude, 4,749 feet..... Greeley.

Ludlow; post village in Las Animas County on Colorado and Southern Railway: altitude, 6,295 feet..... Spanish Peaks.

Ludlum; village in Yuma County.

Lujane; post village in Montrose County.

Lula; village in Grand County.

Lulu; pass between Larimer and Grand counties.

Lump; gulch in Gilpin County, tributary to South Boulder Creek..... Blackhawk.

Lungens; creek in Saguache County, a left-hand branch of Saguache River.

Luning; arroyo in Las Animas County, tributary to Purgatory River..... Elmoro.

Lupton; station in Weld County on Union Pacific Railroad; population in 1900, 214; altitude, 4,909 feet..... Greeley.

Luton; creek in Chester County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Lyden; creek in Jefferson County, a left-hand branch of Ralston Creek, tributary to South Platte River.

Lykins; gulch in Boulder County..... Niwot.

Lynch Run; in Routt County, a left-hand branch of South *Fork Williams* River.

Atlas sheet.

Lynn; station in Las Animas County on Colorado and Southern Railway; altitude, 6,339 feet ..... Spanish Peaks.

Lyons; post village in Boulder County on Burlington and Missouri River Railroad; population in 1900, 547; altitude, 5,349 feet..... Boulder.

Lytle; post village in El Paso County.

McAllisters; station in Eagle County on Denver and Rio Grande Railroad.

McCall; lake in Boulder County ..... Niwot.

McCarry; gulch in Rio Blanco County, tributary to Piceance Creek.

McCarty Basin; valley in San Juan County..... Silverton.

McCauley; peak in San Juan Mountains, La Plata County; altitude, 13,551 feet..... Needle Mountains.

McClellan; mountain in Front Range, Summit County; altitude, 13,423 feet.

McClelland; station in Larimer County on Colorado and Southern Railway; altitude, 5,053 feet.

McCourt; station in Fremont County on Florence and Cripple Creek Railroad; altitude, 6,478 feet.

McCoy; post village in Eagle County.

McElmo; creek in Montezuma County, a left-hand branch of Hovenweep Creek, tributary to San Juan River.

McElmo; post village in Montezuma County.

McGee; station in Chaffee County, on the Colorado Midland, and the Denver and Rio Grande railroads; altitude, 8,658 feet.

McGinty; station in Costilla County on Denver and Rio Grande Railroad; altitude, 7,553 feet.

McIntire; creek in Larimer County, a left-hand branch of Laramie River.

McIntosh; lake in Boulder County ..... Niwot.

McIntyre; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

McIntyre; mountain in Park County ..... Pikes Peak.

McKinney; town in Teller County.

McKissicks; town in Weld County.

McKissock; creek in Larimer County, a left-hand branch of Buckhorn Creek, tributary to Thompson Creek.

McMillan; peak in San Juan Mountains, San Juan County; altitude, 12,800 feet..... Silverton.

McMillan; town in Huerfano County.

McNulty; gulch in Summit County, tributary to Tenmile Creek. Tenmile District Special.

Maber; village in Montrose County.

Mac; gulch in Fremont County, tributary to Currant Creek .. Pikes Peak.

Machias; station in Kit Carson County on Chicago, Rock Island and Pacific Railway; altitude, 4,407 feet. Post-office, Claremont.

Mack; post village in Mesa County.

Macks; butte in Sedgwick County.

Macomber; peak in San Juan County ..... Silverton.

Madden; creek in La Plata County, a right-hand branch of La Plata River..... La Plata.

Atlas sheet.

Madden; peak on boundary between Montezuma and La Plata counties ..... La Plata.
Madenos; creek in Saguache County, a left-hand branch of Mosca Creek ..... Huerfano Park.
Madenos; pass in Huerfano County ..... Huerfano Park.
Madera; station in Gunnison County on Denver and Rio Grande Railroad.
Madrid; post village in Las Animas County on Colorado and Wyoming Railway; altitude, 6,361 feet ..... Spanish Peaks.
Maggie; gulch in San Juan County, a left-hand branch of Animas River ..... Silverton.
Maggie Gulch; station in San Juan County on Silverton Northern Railroad.
Magnetic; gulch in Montezuma County, tributary to Bear Creek ..... La Plata.
Magnet Park; valley in Clear Creek County; altitude, 10,212 feet ..... Georgetown.
Magnolia; post village in Boulder County ..... Blackhawk.
Magnolia; station in Adams County on Union Pacific Railroad; altitude, 5,334 feet ..... Denver.
Magote; post village in Conejos County.
Magpie; gulch in San Miguel County, tributary to Bilk Creek. Telluride.
Maher; post village in Montrose County.
Mainard; town in Mesa County.
Maitland; post village in Huerfano County on Denver and Rio Grande Railroad.
Majestic; post village in Las Animas County on Colorado and Southern Railway.
Malachite; post village in Huerfano County ..... Huerfano Park.
Malcolm; lake in Ouray County ..... Silverton.
Maldonado; post village in Las Animas County.
Malta; post village in Lake County on Denver and Rio Grande Railroad; altitude, 9,570 feet ..... Leadville.
Mam; creek in Garfield County, a left-hand branch of Grand River, originating in East and Middle creeks.
Mammoth; canyon in Garfield County, tributary to Grand River.
Mammoth; hill in Gilpin County ..... Central City Special.
Manassa; post town in Conejos County; population in 1900, 739.
Manchester; lake in Gilpin County ..... Blackhawk.
Manchester; town in Denver County on Colorado and Southern Railway.
Mancos; post town in Montezuma County on Denver and Rio Grande Railroad; population in 1900, 383; altitude, 6,996 feet.
Manhattan; village in Larimer County.
Manila; station in Arapahoe County on Union Pacific Railroad.
Manitou; post town in El Paso County, on the Colorado Midland, the Manitou and Pikes Peak, and the Denver and Rio Grande railroads; population in 1900, 1,303; altitude 6,307 *feet* ..... Colorado Springs.

Atlas sheet.

Manitou and Pikes Peak Railway, cogwheel line between Manitou and the summit of Pikes Peak.

Manitou Iron Spring; station on Colorado Midland Railway; altitude, 6,538 feet.

Manitou Junction; station in El Paso County on Colorado and Southern Railway; altitude, 6,335 feet ..... Colorado Springs.

Manitou Park; valley in Teller County ..... Platte Canyon.

Manoa; post village in Fremont County.

Mansfield; town in Garfield County; altitude, 6,673 feet.

Manville; station in Prowers County on Atchison, Topeka and Santa Fe Railway ..... Granada.

Manzanares; town in Costilla County.

Manzanola; post village in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,249 feet.

Marble; post town in Gunnison County; population in 1900, 101.

Marcellina; pass in Gunnison County ..... Anthracite.

Marcellina, Mount; in Elk Mountains, Gunnison County; altitude, 11,349 feet ..... Anthracite.

Margaret; town in Costilla County.

Marigold; village in Teller County ..... Pikes Peak.

Marion; town in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,533 feet.

Marion; station in Larimer County on Colorado and Southern Railway.

Mariposa; creek in Archuleta County, a right-hand branch of San Juan River.

Marius; village in Gunnison County; altitude, 8,710 feet.

Marmot; peak in Chaffee County; altitude, 11,841 feet.

Maroon; creek in Pitkin County, a left-hand branch of Roaring Fork, tributary to Grand River ..... Aspen.

Maroon; lake in Pitkin County ..... Aspen.

Maroon; peak in Elk Mountains, Pitkin County; altitude, 14,126 feet ..... Aspen.

Marshall; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.

Marshall; pass in Sawatch Range, between Chaffee and Saguache counties.

Marshall; station in Boulder County on Colorado and Southern Railway; altitude, 5,500 feet. Post-office, Gorham ..... Denver.

Marshall; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,018 feet.

Marshall Basin; valley in San Miguel County ..... Telluride.

Marshall Junction; station in Boulder County, on the Colorado and Southern and the Union Pacific railroads ..... Denver.

Marshall Park; village in Clear Creek County.

Marshall Pass; station in Saguache County on Denver and Rio Grande Railroad; altitude, 10,846 feet.

Martin; post village in Grand County on Atchison, Topeka and Santa Fe Railway; altitude, 3,720 feet.

Martinez Plaza; village in Las Animas County ..... Spanish Peaks.

Martinsen; station in Las Animas County on Colorado and Southern Railway; altitude, 6,697 feet ..... Spanish Peaks.

Atlas sheet.

Marvine; creek in Rio Blanco County, a left-hand branch of White River; discharge near Buford, April 26 to October 13, 1904, 51,090 acre-feet.

Marvine; lakes in Rio Blanco County.

Marvine; village in Rio Blanco County.

Marvine, Mount; in White River Plateau, Rio Blanco County; altitude, 12,045 feet.

Maryland; mountain in Gilpin County; altitude, 9,200 feet... Central City Special.

Mason; canyon in Las Animas County, tributary to Purgatory River..... Timpas.

Masonville; post village in Larimer County.

Massive, Mount; in Sawatch Range, Lake County; altitude, 14,424 feet..... Leadville.

Masters; station in Weld County on Union Pacific Railroad; altitude, 4,451 feet.

Mastodon; gulch in San Juan County, tributary to West Fork Cinnamon Creek..... Silverton.

Matterhorn; peak in San Juan Mountains, Hinsdale County; altitude, 13,589 feet..... Lake City.

Mattison; station in Elbert County on Chicago, Rock Island and Pacific Railway; altitude, 5,787 feet..... Limon.

Mavricio; canyon in Las Animas County, a left-hand branch of Apishapa River..... Spanish Peaks.

Maxey; post village in Baca County.

Maxwell; creek in Chaffee County, a right-hand branch of Arkansas River.

Maxwell; Spanish grant of land in southern part of Las Animas County..... Elmoro.

Maxwell; village in Las Animas County.

Maximilian; gulch in Clear Creek County, tributary to Chicago Creek..... Georgetown.

May; creek in Huerfano County, a left-hand branch of Huerfano River..... Huerfano Park.

Maybell; post village in Routt County.

Mayfield; station in Ouray County on Denver and Rio Grande Railroad.

Mayflower; gulch in Summit County, tributary to Tenmile Creek..... Leadville.

Mayflower; hill in Summit County..... Tenmile District Special.

Mayne; post village in Huerfano County on Colorado and Southern Railway; altitude, 6,436 feet.

Mayne Junction; station in Huerfano County on Denver and Rio Grande Railroad.

Mayo; station on Colorado and Southern Railway; altitude, 10,172 feet.

Maysville; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,310 feet.

Meadow; creek in Larimer County, a right-hand branch of Cache la Poudre River.

Meadow; springs in Costilla County.

Mears; station in Chaffee County on Denver and Rio Grande *Railroad; altitude*, 8,434 feet.

Atlas sheet.

Mears Junction; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,421 feet.

Medicine Bow; range in the northern part of the State, a spur from Front Range separating North Platte River from Laramie River.

Medicine Bow Forest Reserve; area, 1,806 square miles.

Medio; station in Pitkin County on Crystal River Railroad; altitude, 8,688 feet.

Medlen; village in Jefferson County.

Meeker; post village and county seat of Rio Blanco County; population in 1900, 507; altitude, 6,182 feet.

Meeker; town in Garfield County on Denver and Rio Grande Railroad.

Meily; village on boundary between Pitkin and Lake counties.

Melville; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River ..... Georgetown

Melvin; lake in Arapahoe County ..... Denver.

Melvin; station in Arapahoe County on Colorado and Southern Railway; altitude, 5,576 feet ..... Denver.

Melvina; hill in Boulder County; altitude, 9,200 feet ..... Boulder.

Mendota; peak in San Miguel County ..... Telluride.

Menefee; mountains, a short range in Montezuma County ..... La Plata.

Menefee; peak in Montezuma County; altitude, 8,812 feet ..... La Plata.

Menefee; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,302 feet.

Menger; village in Las Animas County ..... Spanish Peaks.

Menoken; station in Montrose County on Denver and Rio Grande Railroad; altitude, 5,544 feet.

Mercer; station in Logan County on Burlington and Missouri River Railroad; altitude, 4,427 feet.

Meredith; hill in Otero County; altitude, 4,400 feet ..... Catlin.

Meredith; post village in Pitkin County on Colorado Midland Railway; altitude, 7,775 feet.

Meredith; station in Otero County on Missouri Pacific Railway; altitude, 4,308 feet ..... Catlin.

Meridian; hill in Park County ..... Georgetown.

Meridian; lake in Gunnison County ..... Crested Butte.

Merino; post village in Logan County on Union Pacific Railroad; altitude, 4,033 feet.

Mesa; county in the western part of the State; bounded on the north by Garfield County, on the east by Pitkin, Gunnison, and Delta counties, on the south by Montrose County, and on the west by Utah. It is traversed by Grand and Gunnison rivers, and consists mostly of plateaus and broad desert valleys. Its area is 3,309 square miles, of which 1½ per cent, or 34,205 acres, were under cultivation in 1900. The population in 1900 was 9,267, and of Grand Junction, the county seat, 3,503. In 1900 the average magnetic declination was 14° 35′ east. The mean annual rainfall is about 13 inches, and the mean annual temperature 45° to 50°.

Mesa; creek in Montrose County, a right-hand branch of Dolores River.

Atlas sheet.

Mesa; creek in Mesa County, a left-hand branch of Plateau Creek, tributary to Grand River.

Mesa; peak in La Plata County; altitude, 9,790 feet..... Durango.

Mesa; peak in Saguache County; altitude, 12,581 feet.

Mesa; post village in Mesa County.

Mesa; station in Adams County on Union Pacific Railroad; altitude, 5,521 feet.

Mesa; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 8,123 feet.

Mesa; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,848 feet.

Mesa de Maya; plateau in the southeastern part of Las Animas County ..... Mesa de Maya.

Mesa Inclinado; plateau sloping northward, forming a part of the north wall of Grand Canyon of the Gunnison in Montrose County.

Mesa Verde; plateau in the southwestern part of the State. It is dissected by Mancos River and its branches, and contains many ruins of the town-building Indians; altitude, 8,500 feet.

Metcalf; station in Park County on Colorado Midland Railway; altitude, 8,068 feet.

Metz; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River ..... Georgetown.

Micanite; post village in Fremont County.

Michigan; river in Larimer County, a right-hand branch of North Platte River.

Michigan; station in Park County on Colorado and Southern Railway; altitude, 9,448 feet.

Michigan; village in Larimer County.

Midas; station in Lake County on Denver and Rio Grande Railroad; altitude, 10,266 feet.

Middle; mountain in San Juan County..... Silverton.

Middle Basin; valley in San Miguel County ..... Telluride.

Middle Creek; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 8,511 feet.

Middle Park; high mountain valley near the center of the State; surface consists of alternating valleys and high ranges of the second order, drained westward by Grand River.

Middle St. Vrain; creek in Boulder County, a left-hand branch of South St. Vrain Creek, tributary to St. Vrain Creek ..... Boulder.

Middleton; village in San Juan County ..... Silverton.

Midland; ridge in Routt County.

Midland; station in Teller County on Colorado Midland Railway ..... Pikes Peak.

Midland Basin; valley in Routt County.

Midland Terminal Railway; line extending from Divide, Teller County, to Cripple Creek, connecting large railway systems with the mining towns.

Midway; station in Teller County on Colorado Springs and *Cripple Creek* District Railway; altitude, 10,484 feet.

Atlas sheet.

Midway; village in Chaffee County; altitude, 7,824 feet.

Midway; village in Gunnison County.

Mildred; village in Montezuma County.

Military Junction; station in Arapahoe County on Denver and Rio Grande Railroad; altitude, 5,316 feet.

Military Park; station in Arapahoe County on Denver and Rio Grande Railroad.

Military Post; station in Arapahoe County on Atchison, Topeka and Santa Fe Railway.

Milk; creek in Routt and Rio Blanco counties, a left-hand branch of Yampa River; discharge near Axial, April 20 to October 31, 1904, 18,140 acre-feet.

Mill; creek in Archuleta County, a left-hand branch of San Juan River.

Mill; creek in Gunnison County, a left-hand branch of North Beaver Creek, tributary to Gunnison River.

Mill; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Mill; creek, a left-hand branch of Clear Creek, tributary to South Platte River.

Mill; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.

Mill; creek in San Juan County, a right-hand branch of Mineral Creek, tributary to Animas River ..... Silverton.

Mill; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,361 feet.

Miller Rock; summit in Boulder County; altitude, 8,633 feet. Boulder.

Millet; station in Washington County on Burlington and Missouri River Railroad.

Mill Gulch; station in Jefferson County on Colorado and Southern Railway; altitude, 5,660 feet.

Millsap; creek in Fremont County, a left-hand branch of Oil Creek, tributary to Arkansas River, heading in West and East forks ..... Pikes Peak.

Milner; pass between Larimer and Grant counties.

Milton; village in Saguache County.

Milwood; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,640 feet.

Minaret; station in Gunnison County on Colorado and Southern Railway.

Miner; gulch in Fremont County, tributary to Currant Creek. Pikes Peak.

Miner; village in Larimer County.

Mineral; county in the southwestern part of the State; bounded on the north by Hinsdale, Saguache, and Rio Grande counties, on the east by Rio Grande County, on the south by Archuleta County, and on the west by Hinsdale County. It includes part of the San Juan Mountains. Its area is 880 square miles, of which one-half of 1 per cent, or 2,929 acres, were under cultivation in 1900. The population in 1900 was 1,913; and of Creede, the county seat, 235. In 1900 the average magnetic declination was 13° 50′ east. The mean annual rainfall is about 11 inches, and the mean annual temperature about 40°.

	Atlas sheet.
Mineral; creek in San Juan County, a right-hand branch of Animas River, heading in South Mineral Creek	Silverton.
Mineral; hill in Teller County	Cripple Creek Special.
Mineral Basin; valley in San Juan County	Silverton.
Mineral Creek; pass in San Juan County; altitude, 11,098 feet.	
Mineral Point; summit in Elk Mountains, Gunnison County; altitude, 12,541 feet	Anthracite.
Mineral Wonder; gulch in La Plata County, tributary to Flagler Fork	Durango.
Mink; creek in Rio Blanco County, a left-hand branch of White River.	
Minneapolis; village in Baca County; altitude, 3,935 feet	Albany.
Minnehaha; station in El Paso county on Manitou and Pikes Peak Railway.	
Minnequa; lake in Pueblo County	Pueblo.
Minnequa; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,795 feet. Post-office, Bessemer.	
Minnesota; creek in Delta County, a left-hand branch of North Fork Gunnison River.	
Minnesota; gulch in San Juan County, tributary to Cement Creek	Silverton.
Minnie; canyon in Otero and Las Animas counties, tributary to Purgatory River	Timpas.
Minnie; gulch in San Miguel County, tributary to San Miguel River	Telluride.
Minnie; gulch in San Juan County, a left-hand branch of Animas River	Silverton.
Minnie; lake in Boulder County	Boulder.
Minto; station in Logan County on Burlington and Missouri River Railroad; altitude, 3,900 feet.	
Minturn; post village in Eagle County on Denver and Rio Grande Railroad; altitude, 9,815 feet.	
Mirage; post village in Saguache County on Denver and Rio Grande Railroad; altitude, 7,618 feet.	
Mirage; station in Lincoln County on Union Pacific Railroad; altitude, 4,877 feet.	
Missouri; gulch in La Plata County, tributary to Florida River	Needle Mountains.
Missouri; gulch in Rio Blanco County, tributary to Piceance Creek.	
Missouri Pacific Railway; one of the large systems of the country. One line enters Colorado at its east boundary and runs to Pueblo.	
Mitchell; creek in Garfield County, a right-hand branch of Grand River.	
Mitchell; post village in Eagle County on Denver and Rio Grande Railroad; altitude, 9,895 feet	Leadville.
Mitotes; canyon in Las Animas County, tributary to Apishapa River	Spanish Peaks.
Mitre; peak on boundary between Teller and Fremont counties	Pikes Peak.
Modoc; gulch in **Hinsdale County, tributary to Henson Creek.**	Lake City.

Atlas sheet.

Modoc; station in Teller County on Florence and Cripple Creek Railroad.

Moffat; post village in Saguache County on Denver and Rio Grande Railroad; altitude, 7,568 feet.

Molas; lake in San Juan County; altitude, 10,488 feet..... Needle Mountains.

Monarch; pass between Gunnison and Chaffee counties.

Monarch; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 10,018 feet.

Monitor; creek in Montrose County, a left-hand branch of Gunnison River.

Monitor; peak in San Juan Mountains, La Plata County; altitude, 13,703 feet..... Needle Mountains.

Monon; post village in Baca County.

Monsoit; station on Colorado and Southern Railway; altitude, 6,400 feet.

Monson; station in Huerfano County on Colorado and Southern Railway.

Mont Alto Park; station in Boulder County on Colorado and Northwestern Railroad ..... Boulder.

Montclair; post town in Denver County; population in 1900, 415.

Monte; station in Lake County on Denver and Rio Grande Railroad.

Montelores; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 8,442 feet..... Rico.

Monte Vista; post village in Rio Grande County on Denver and Rio Grande Railroad; population in 1900, 556; altitude, 7,653 feet.

Montezuma; southwestern county of the State; bounded on the north by Dolores County, on the east by La Plata County, on the south by New Mexico, and on the west by Utah. It consists almost entirely of plateaus, spurs, and and narrow canyons, and includes the Ute Indian Reservation. The area of the county is 2,113 square miles, of which 1 per cent, or 15,204 acres, were under cultivation in 1900. The population in 1900 was 3,058; and of Cortez, the county seat, 125. In 1900 the average magnetic declination was 13° 20′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Montezuma; post village in Summit County; population in 1900, 40; altitude, 10,295 feet.

Montezuma; valley in Montezuma County.

Montezuma Forest Reserve; area, 901 square miles.

Montrose; county in the western part of the State; bounded on the north by Mesa and Delta counties, on the east by Gunnison and Ouray counties, on the south by San Miguel and Ouray counties, and on the west by Utah. The eastern part includes plains in the valley of Gunnison River and also the broad and fertile valley of the Uncompahgre, from which rises Uncompahgre Plateau, while to the west the land drops to lower plains, through which Dolores and San Miguel rivers have cut valleys. The area is 2,290 square miles, of which 2 per cent, or 36,884 acres, were under cul-

Atlas sheet.

Montrose—Continued.
tivation in 1900. The population in 1900 was 4,535; and of Montrose, the county seat, 1,217. In 1900 the average magnetic declination was 13° 40′ east. The mean annual rainfall is about 13 inches, and the mean annual temperature 50° to 55°.

Montrose; county seat of Montrose County on Denver and Rio Grande Railroad; altitude, 5,801 feet.

Montville; village in Costilla County.

Monument; bluff in Mineral County.

Monument; butte in Routt County.

Monument; creek in El Paso County, a left-hand branch of Fountain Creek, tributary to Arkansas River..... Colorado Springs.

Monument; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

Monument; hill in La Plata County; altitude, 10,820 feet.... Durango.

Monument; post town in El Paso County, on the Denver and Rio Grande and the Atchison, Topeka and Santa Fe railways; population in 1900, 156; altitude, 7,001 feet..... Castle Rock.

Monument Park; valley in El Paso County, north of Colorado Springs, containing many curious monuments of sandstone produced by wind erosion.

Moon Anchor; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Moores; creek in Logan and Sedgwick counties, a left-hand branch of South Platte River.

Mooreville; station in Jefferson County on Colorado and Southern Railway..... Denver.

Moqui; post village in Montezuma County.

Moraine; lake in El Paso County; altitude, 10,268 feet..... Colorado Springs.

Moraine; town in Larimer County; altitude, 7,900 feet.

Moraine Park; post village in Larimer County.

Morgan; county in the northeastern part of the State; bounded on the north by Weld and Logan counties, on the east by Logan and Washington counties, on the south by Washington and Adams counties, and on the west by Weld County. It is traversed east and west by the Union Pacific and the Burlington and Missouri River railroads. The wide valley of the South Platte extends across the center, and to the north and south are rolling plains. The area is 1,264 square miles, of which 5 per cent, or 43,282 acres, were under cultivation in 1900. The population in 1900 was 3,268; and of Fort Morgan, the county seat, 634. In 1900 the average magnetic declination was 13° 40′ east. The mean annual rainfall is about 11 inches, and the mean annual temperature 50° to 55°.

Morland; town in El Paso County.

Morley; post village in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 6,739 feet ..... Spanish Peaks.

Morris; station in Garfield County on Denver and Rio Grande Railroad.

Morrison; mountain in Jefferson County; altitude, 7,900 feet. Denver.

Atlas sheet.

Morrison; post village in Jefferson County on Colorado and Southern Railway; altitude, 5,766 feet ..... Denver.

Morse; town in Prowers County on Atchison, Topeka and Santa Fe Railway; altitude, 3,566 feet.

Mortimer; station in Costilla County on Denver and Rio Grande Railroad; altitude, 8,092 feet. Post-office, Trinchera.

Mosca; creek in Saguache County, flowing into a sink.

Mosca; pass in Sangre de Cristo Range, Huerfano and Saguache counties; altitude, 9,713 feet ..... Huerfano-Park.

Mosca; post village in Costilla County on Denver and Rio Grande Railroad; altitude, 7,562 feet.

Moses; creek, a left-hand branch of Frazer Creek, tributary to Grand River.

Mosquito; gulch in Park County, tributary to South Platte River..... Leadville.

Mosquito; pass in Park Range, between Lake and Park counties; altitude, 13,185 feet ..... Leadville.

Mosquito; peak in Park Range, on boundary between Park and Lake counties; altitude, 13,794 feet..... Leadville.

Moss, Mount; in La Plata Mountains, Montezuma County... La Plata.

Mound; village in Teller County..... Pikes Peak.

Mounds; station in Gunnison County, on Denver and Rio Grande Railroad; altitude, 7,786 feet.

Mountain; creek in Gunnison County, a right-hand branch of Gunnison River.

Mountaindale; village in Park County.

Mountaineer; creek in San Juan County, a left-hand branch of Cunningham Creek, tributary to Animas River ..... Silverton.

Mountainvale; village in Mesa County.

Mountainview; station in El Paso County on Manitou and Pikes Peak Railway.

Mount Carbon; post village in Gunnison County on Colorado and Southern Railway; altitude, 5,553 feet..... Anthracite.

Mount Carrizo; plateau in Las Animas County ..... Mount Carrizo.

Mountearl; village in Larimer County.

Mount Olivet; station in Jefferson County on Colorado and Southern Railway.

Mount Princeton; station in Chaffee County on Colorado and Southern Railway; altitude, 8,179 feet.

Mount Vernon; creek in Jefferson County, a left-hand branch of Bear Creek, tributary to South Platte River.

Muckawanago; town in Pitkin County.

Mud; canyon in Montezuma County, tributary to Rio Mancos.

Mud; creek in Bent County, a right-hand branch of Arkansas River. Two Butte. Lamar.

Mud; creek in Gunnison County, a right-hand branch of Smith Creek.

Muddy; creek in Bent County, a left-hand branch of Rule Creek, tributary to Arkansas River ..... Higbee.

Muddy; creek in Custer and Huerfano counties, a left-hand branch of Huerfano River..... Huerfano Park.

Atlas sheet.

Muddy; creek in Grand County, a right-hand branch of Grand River.

Muddy; creek in La Plata County, a right-hand branch of Big Bear Creek, tributary to San Miguel River ..... Telluride.

Muddy; creek in Pueblo County, a left-hand branch of Greenhorn Creek, tributary to St. Charles River ..... Walsenburg.

Muddy; gap in Bent County ..... Higbee.

Muddy Creek; pass between Larimer and Grand counties; altitude, 8,772 feet.

Mud Lake Basin; valley in San Miguel County ..... Telluride.

Mudsill; town in Park County on Colorado and Southern Railway; altitude, 11,048 feet. Post-office, Doran.

Muggins; gulch in Larimer County, tributary to Little Thompson Creek.

Muggins; park in Larimer County.

Muldoon; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,550 feet.

Mulvane; village in Baca County ..... Two Butte.

Mumm; mountains in Larimer County.

Muriel; post village in Huerfano County.

Murphy; creek in Arapahoe County, a left-hand branch of Sand Creek, tributary to South Platte River ..... Denver.

Murphy; station in Dolores County on Denver and Rio Grande Railroad.

Murphy; station in Teller County on Midland Terminal Railway.

Murrell; station in San Juan County on Denver and Rio Grande Railroad.

Music; pass in Sangre de Cristo Range, Custer County ..... Huerfano Park.

Muskig; town in El Paso County on Colorado Midland Railway; altitude, 8,742 feet.

Mustang; creek in Kiowa County, a right-hand branch of Adobe Creek, tributary to Arkansas River ..... Las Animas.

Mustang; creek in Las Animas County, a right-hand branch of Two Butte Creek, tributary to Arkansas River ..... Mount Carrizo.

Mustang; creek in Pueblo County, a left-hand branch of Apishapa River, tributary to Arkansas River ..... Apishapa.

Namaqua; station in Larimer County on Colorado and Southern Railway.

Namouna; town in Cheyenne County on Union Pacific Railroad; altitude, 4,143 feet.

Nantes; station in Weld County on Union Pacific Railroad; altitude, 4,755 feet ..... Greeley.

Naomi; village in Summit County.

Narraquinep; creek in Dolores County, a left-hand branch of Dolores River.

Narraquinep; hill in Dolores County; altitude, 8,141 feet.

Narrow Grade; creek in Gunnison County, a left-hand branch of Lake Fork Gunnison River ..... Lake City.

Nast; village in Pitkin County on Colorado Midland Railway; altitude, 9,061 feet.

Nate; creek in Ouray County, a left-hand branch of Low Creek, *tributary* to Cow Creek ..... Ouray.

	Atlas sheet.
Nathrop; post village in Chaffee County, on the Denver and Rio Grande and the Colorado and Southern railways; altitude, 7,686 feet.	
Naturita; creek in Montrose County, a left-hand branch of San Miguel River.	
Naturita; post village in Montrose County.	
Navajo Basin; valley in San Miguel County	Telluride.
Navesink; peak in Elkhead Mountains; altitude, 9,510 feet.	
Naylor; lake in Clear Creek County; altitude, 11,348 feet	Georgetown.
Nebo, Mount; in San Juan Mountains, San Juan County; altitude, 13,192 feet	Needle Mountains.
Nederland; post village in Boulder County; altitude, 8,263 feet.	
Needle; buttes in Jefferson County	Platte Canyon.
Needle; creek in La Plata County, a left-hand branch of Animas River	Needle Mountains.
Needle; creek in Saguache County, a right-hand branch of Tomichi Creek, tributary to Gunnison River.	
Needle; mountains, group of San Juan Mountains, San Juan and La Plata counties	Needle Mountains.
Needleton; post village in La Plata county on Denver and Rio Grande Railroad; altitude, 8,127 feet	Needle Mountains.
Neff; lake in Weld County	Greeley.
Nellie; creek in Hinsdale County, a left-hand branch of Henson Creek	Lake City.
Nemo; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 5,675 feet.	
Nepesta; post village in Pueblo County on Atchison, Topeka and Santa Fe Railway; altitude, 4,384 feet	Nepesta.
Neptune; creek in La Plata County, a left-hand branch of La Plata River	La Plata.
Nero; hill in Otero County; altitude, 4,610 feet.	
Neuman; lake in Weld County	Greeley.
Nevada; gulch in Gilpin County, tributary to North Clear Creek	Central City Special.
Nevada; hill in Gilpin County	Central City Special.
Nevadaville; town in Gilpin County; population in 1900, 823.	Central City Special.
New Castle; post village in Garfield County on Denver and Rio Grande Railroad; population in 1900, 431; altitude, 5,552 feet.	
Newdale; station in Otero County on Atchison, Topeka and Santa Fe Railway.	
Newett; post village in Chaffee County, on the Colorado Midland and the Denver and Rio Grande railroads; altitude, 9,135 feet.	
Newlin; creek in Douglas County, a left-hand branch of Cherry Creek, tributary to South Platte River	Denver.
Newmire; post village in San Miguel County on Denver and Rio Grande Railroad. Railroad name, Wilson	Telluride.
Newton; post village in Yuma County.	
New Windsor; post village in Weld County on Colorado and Southern Railway; altitude, 4,796 feet. Railroad name, Windsor	Greeley.
New York Basin; valley in La Plata County	Needle Mountains.

Atlas sheet.

Niagara; gulch in San Juan County, tributary to Animas River..... Silverton.

Niagara; peak in San Juan Mountains on boundary between Hinsdale and San Juan counties..... Silverton.

Nichols; station in Huerfano County on Denver and Rio Grande Railroad.

Nigger Hill; station in Garfield County on Denver and Rio Grande Railroad..... Central City Special.

Night Hawk; station in Douglas County on Colorado and Southern Railway.

Nipple; mountain in Fremont County; altitude, 10,068 feet.... Pikes Peak.

Niwot; post village in Boulder County on Colorado and Southern Railway; altitude, 5,100 feet..... Niwot.

Noland; village in Boulder County.

Noonans; peak in Fremont County..... Canyon City.

Norma; village in Rio Grande County.

Norrie; post village in Pitkin County on Colorado Midland Railway; altitude, 8,431 feet.

North; canyon in Baca County, tributary to Cimarron River. Springfield.

North; creek, a left-hand branch of St. Charles River..... Pueblo.

North Baldy; summit in Costilla County.

North Beaver; creek in Gunnison County, a right-hand branch of Gunnison River.

North Boulder; creek in Boulder County, a left-hand branch of Boulder Creek, tributary to St. Vrain Creek..... Boulder.

North Boxelder; creek in Larimer County, a left-hand branch of Boxelder Creek, tributary to Cache La Poudre River.

North Butte; creek in Prowers County, fork of Butte Creek, tributary to Arkansas River..... Albany.

North Cheyenne; creek in El Paso County, fork of Cheyenne Creek, tributary to Fountain Creek..... Colorado Springs.

North Cheyenne; station in El Paso County on Colorado Springs and Cripple Creek District Railway.

North Clear; creek in Jefferson and Gilpin counties, a left-hand branch of Clear Creek, tributary to South Platte River. Blackhawk. Central City Special.

North Fork Gunnison; river in Delta and Gunnison counties, a right-hand branch of Gunnison River; discharge, near Hotchkiss for 1904, 360,100 acre-feet.

North Fort Morgan; station in Morgan County on Union Pacific Railroad.

North Italian; mountain in Elk Mountains, Gunnison County; altitude, 13,225 feet..... Crested Butte.

North Mam; creek, a left-hand branch of Grand River.

North Mam; summit on Battlement Mesa, Garfield County, altitude, 10,973 feet.

North Park; level mountain valley in the northern part of the State, drained northward by North Platte River; average altitude, 8,000 feet.

North Platte; river in Colorado, Wyoming, and Nebraska, one of the two forks of Platte River; heads in North Park, flows nearly north to its junction with the Sweetwater in

Atlas sheet.

North Platte—Continued.
Wyoming, then turns somewhat south of east, and after a long course joins the South Platte in western Nebraska near the city of North Platte; discharge at Saratoga, Wyo., January 1 to December 10, 1904, 936,800 acre-feet.

North Rattlesnake; butte in Huerfano County; altitude, 6,442 feet ..... Apishapa.

Northrop; station in Boulder County on Union Pacific Railroad.

North Rush; creek, a left-hand branch of Rush Creek, tributary through Big Sandy Creek to Arkansas River.

North St. Vrain; creek in Boulder County, a left-hand branch of St. Vrain Creek, tributary to South Platte River ..... Boulder.

North Sheep; mountain on boundary between Summit and Eagle counties; altitude, 12,439 feet. ..... Tenmile District Special.

North Star; post village in Gunnison County.

North Table Mountain; volcanic mesa near Golden, Jefferson County; altitude, 6,650 feet ..... Denver.

North Tarryall; peak in Park County.

North Veta; creek in Huerfano County, a left-hand branch of Cuchara River, tributary to Huerfano River ..... Huerfano Park.

Norton; post village in Elbert County.

Norwood; post village in San Miguel County.

Notaway; station in San Juan County on Denver and Rio Grande Railroad.

No Thoroughfare; creek in Mesa County, a left-hand branch of Uncompahgre River.

Nourse; creek in Hinsdale County, a left-hand branch of Lake Fork Gunnison River ..... Lake City.

Nucla; post village in Montrose County.

Nugget; village in Gilpin County.

Nugget; hill in Boulder County; altitude, 8,589 feet ..... Boulder.

Numa; station in Otero County on Missouri Pacific Railway; altitude, 4,325 feet ..... Catlin.

Nunn; station in Weld County on Union Pacific Railroad; altitude, 5,188 feet.

Nussbaum; spring in Pueblo County ..... Pueblo.

Nutria; station in Archuleta County on Denver and Rio Grande Railroad.

Nyburg; station in Pueblo County on the Atchison, Topeka and Santa Fe and the Missouri Pacific railways; altitude, 4,548 feet ..... Nepesta.

Oak; creek in Fremont County, a right-hand branch of Arkansas River ..... Canyon City.

Oak; creek in Huerfano County, a right-hand branch of Huerfano River ..... Huerfano Park.

Oak; creek in Larimer County, a left-hand branch of Yampa River.

Oak; creek in Ouray County, a left-hand branch of Uncompahgre River ..... Ouray.

Oak; creek in Routt County, a left-hand branch of Bear Creek.

Oak Creek; town in Fremont County on Denver and Rio Grande Railroad. Post-office, Williamsburg.

Atlas sheet.

Oak Creek Junction; station in Fremont County on Denver and Rio Grande Railroad; altitude, 5,194 feet.

Oakes; town in Arapahoe County. Post-office, Sullivan.

O'Brien Junction; station in Douglas County on Denver and Rio Grande Railroad.

Observatory Cone; summit in Elk Mountains, Gunnison County; altitude, 8,866 feet.

Occidental; station in Huerfano County on Denver and Rio Grande Railroad.

Officers; station in Summit County on Denver and Rio Grande Railroad.

Oh-be-joyful; gulch in Gunnison County, tributary to Slate River ..... Anthracite.

Oh-be-joyful; peak in Gunnison County ..... Anthracite.

Ohio; creek in Gunnison County, a right-hand branch of Gunnison River.

Ohio; gulch in San Juan County, tributary to Cement Creek .. Silverton.

Ohio; pass in Gunnison County; altitude, 10,033 feet ..... Anthracite.

Ohio; peak in Elk Mountains, Gunnison County; altitude, 12,251 feet ..... Anthracite.

Ohio; peak in San Juan Mountains, San Juan County ..... Silverton.

Ohio; post village in Gunnison County on Colorado and Southern Railway.

Ohio City; station in Gunnison County on Colorado and Southern Railway; altitude, 8,556 feet.

Ohwiler; ridge in La Plata County ..... La Plata.

Oil; creek in Fremont County, a left-hand branch of Arkansas River. Pikes Peak. Canyon City.

Ojo; station in Costilla County on Denver and Rio Grande Railroad ..... Huerfano Park.

Ojo Vallecito; spring in Dolores County; altitude, 6,400 feet.

Olathe; post village in Montrose County on Denver and Rio Grande Railroad; altitude, 5,355 feet.

Old Baldy; peak in Sangre de Cristo Range, Costilla County; altitude, 14,176 feet ..... Huerfano Park.

Old Baldy; summit in San Juan Mountains, Ouray County.

Olivet, Mount; in Jefferson County.

Olney; post village in Otero County on Missouri Pacific Railway; altitude, 4,372 feet. Railroad name, Olney Springs .. Catlin.

Olympus, Mount; in Larimer County.

Omer; post village in Otero County.

Oneco; village in Routt County.

Onion; creek in Montrose County, a right-hand branch of Uncompahgre River.

Ophir; pass in San Juan County ..... Telluride.

Ophir; post town in San Miguel County on Denver and Rio Grande Railroad; population in 1900, 127; altitude, 9,224 feet ..... Telluride.

Ophir Needles; summits in San Juan Mountains, San Miguel County ..... Telluride.

Ophir Station; in San Miguel County on Denver and Rio Grande Railroad ..... Telluride.

Atlas sheet.

Oranola; station in Kit Carson County on Chicago, Rock Island and Pacific Railway.

Orchard; post village in Morgan County on Union Pacific Railroad; altitude, 4,403 feet.

Orda Spur; station in El Paso County on Colorado Midland Railway.

Ordway; post town in Otero County on Missouri Pacific Railway; population in 1900, 138; altitude, 4,300 feet.

Oredell, station in Boulder County on Colorado and Northwestern Railway; altitude, 5,723 feet ..... Boulder.

Organ; mountain in San Juan Mountains, La Plata County... Needle Mountains.

Orient; village in Saguache County on Denver and Rio Grande Railroad; altitude, 9,014 feet.

Orient Junction; station in Saguache County on Denver and Rio Grande Railroad; altitude, 7,963 feet.

Orlando; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 5,871 feet.

Orman; station in Huerfano County on Denver and Rio Grande Railroad.

Ormega; station in Otero County on Atchison, Topeka and Santa Fe Railway.

Ormus; mountain in San Juan Mountains; altitude, 12,185 feet.

Orno, Mount; in Rio Blanco County.

Oro; village in Lake County ..... Leadville.

Oro Fino; summit in La Plata County; altitude, 10,640 feet... Durango.

Oro Fino Mill; village in La Plata County ..... Durango.

Oro Grande; station in Summit County on Colorado and Southern Railway.

Oro Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,972 feet.

Oro Junta; station in Fremont County on Florence and Cripple Creek Railroad; altitude, 5,663 feet.

Orson; village in Mesa County.

Ortega; station in Eagle County on Denver and Rio Grande Railroad; altitude, 6,828 feet.

Ortiz; post village in Conejos County.

Osier; post village in Conejos County on Denver and Rio Grande Railroad; altitude, 9,625 feet.

Oso, Mount; in San Juan Mountains, Hinsdale County; altitude, 13,640 feet.

Otero; county in the southeastern part of the State; bounded on the north by Lincoln County, on the east by Kiowa and Bent counties, on the south by Las Animas County, and on the west by Pueblo County. Its surface consists of rolling plains, traversed east and west by Arkansas River and by the Missouri Pacific and the Atchison, Topeka and Santa Fe railways. Its area is 2,042 square miles, of which 5 per cent, or 68,036 acres, were under cultivation in 1900. The population in 1900 was 11,522; and of La Junta, the county seat, 2,513. In 1900 the average magnetic declination was 12° 30′ east. The mean annual rainfall is about 13 inches, and the mean annual temperature 45° to 50°.

Atlas sheet.

Otis; post village in Washington County on Burlington and Missouri River Railroad; altitude, 4,348 feet.

Otis; station in Fremont County on Denver and Rio Grande Railroad.

Otto; gulch in San Juan County, tributary to Animas River... Silverton.

Otto; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,202 feet.

Ouray; county in the southwestern part of the State; bounded on the north by Montrose County, on the east by Gunnison County, on the south by Hinsdale, San Juan, and San Miguel counties, and on the west by Montrose and San Miguel counties. The southern part consists of high mountains of the San Juan group, while the northern half includes a part of the valley of Uncompahgre River. Its area is 557 square miles, of which 3 per cent, or 11,184 acres, were under cultivation in 1900. The population in 1900 was 4,731; and of Ouray, the county seat, 2,196. In 1900 the average magnetic declination was 13° 45′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature about 40°.

Ouray; county seat of Ouray County on Denver and Rio Grande Railroad; altitude, 7,710 feet ..... Ouray.

Ouray; peak in Sawatch Range, Chaffee County; altitude, 13,956 feet.

Ouray Junction; station in Montrose County on Denver and Rio Grande Railroad; altitude, 5,826 feet.

Overland, mountain in Boulder County; altitude, 8,700 feet.. Boulder.

Overland; post village in Denver County on Colorado and Southern Railway. Railroad name, Overland Park.

Overland; village in Garfield County.

Overland Park; station in Denver County on Denver and Rio Grande Railroad. Post-office, Overland.

Overland Park Junction; station in Denver County on Denver and Rio Grande Railroad; altitude, 5,262 feet.

Overlook Point; summit in San Juan Mountains, La Plata County; altitude, 12,995 feet ..... Needle Mountains.

Oversteg; post village in Gunnison County on Denver and Rio Grande Railroad.

Overton; station in Pueblo County on Colorado and Southern Railway; altitude, 4,902 feet ..... Pueblo.

Ovid; station in Sedgwick County on Union Pacific Railroad.

Owen; lake in Boulder County ..... Niwot.

Owen, Mount; in Elk Mountains, Gunnison County; altitude, 13,102 feet ..... Anthracite.

Owen Basin; valley in Montezuma County..... La Plata.

Owiyukuts; plateau in Routt County.

Owl; creek in Ouray and Gunnison counties, a left-hand branch of West Fork, tributary to Cimarron River..... Ouray.

Owl; gulch in Hinsdale County, tributary to Henson Creek... Lake City.

Owl; gulch in San Miguel County, tributary to San Miguel River..... Telluride.

Owl; mountain in Larimer County.

Atlas sheet.

Owl; post town in Larimer County.
Oyster; lake in Rio Blanco County.
Packard; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special.
Packers; gap in Otero County ..... Timpas.
Pacona; station in Saguache County on Denver and Rio Grande Railroad.
Pactolus; village in Gilpin County ..... Blackhawk.
Padroni; station in Logan County on Burlington and Missouri River Railroad; altitude, 3,992 feet.
Page; creek in Routt County, a left-hand branch of South Fork Williams River.
Pagoda; peak on White Mountain Plateau, Rio Blanco County; altitude, 11,257 feet.
Pagoda; post village in Routt County; altitude, 6,500 feet.
Pagosa; peak in San Juan Mountains, Mineral County; altitude, 12,674 feet.
Pagosa Junction; post village in Archuleta County on Denver and Rio Grande Railroad; altitude, 6,259 feet.
Pagosa Springs; post town and county seat of Archuleta County; population in 1900, 367; altitude, 7,095 feet.
Paine; mountain in Front Range, Clear Creek County ..... Georgetown.
Paine; ridge in La Plata Mountains, La Plata County ..... La Plata.
Palisades; post village in Mesa County, on the Denver and Rio Grande and the Colorado Midland railways; altitude, 4,729 feet.
Palisades, The; summits in Larimer County; altitude, 8,200 feet.
Pallas; post village in Routt County.
Palmer; lake in El Paso County.
Palmer Lake; town in El Paso County on Denver and Rio Grande Railroad; population in 1900, 166; altitude, 7,224 feet. Post-office, Palmer ..... Castle Rock.
Palmetto; gulch in San Juan County, tributary to Henson Creek. Silverton.
Palo; station in Fremont County on Denver and Rio Grande Railroad; altitude, 7,139 feet.
Pando; post village in Eagle County on Denver and Rio Grande Railroad; altitude, 9,199 feet.
Pandora; village in San Miguel County; altitude, 8,995 feet .. Telluride.
Paoli; station in Phillips County on Burlington and Missouri River Railroad; altitude, 3,873 feet.
Paonia; post village in Delta County; altitude, 5,684 feet.
Papoose; creek in Dolores County, a left-hand branch of Horse Creek, tributary to East Dolores River ..... Rico.
Parachute; station in Garfield County, on the Denver and Rio Grande and the Colorado Midland railways; altitude, 5,105 feet.
Paradise Basin; valley in San Juan County ..... Telluride.
Paradox; post village in Montrose County.
Paradox; valley in Montrose County.
Pargin; town in La Plata County.
Park; creek in Boulder County, a right-hand branch of Cave Creek, tributary to St. Vrain Creek ..... Boulder.

Atlas sheet.

Park; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Park; creek in Park and Mesa counties, a left-hand branch of Plateau Creek, tributary to Grand River.

Park; county in the center of the State; bounded on the north by Summit and Clear Creek counties, on the east by Jefferson and Teller counties, on the south by Fremont County, and on the west by Park Range. It includes South Park, extending to the summits of the bordering ranges. Its area is 2,084 square miles, of which 3 per cent, or 40,258 acres, were under cultivation in 1900. The population in 1900 was 2,998; and of Fairplay, the county seat, 319. In 1900 the average magnetic declination was 14° 15′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature about 40°.

Park; gulch in Park County, tributary to Tarryall Creek.

Park; range of mountains forming the west wall of Middle and South parks; includes a number of peaks which exceed 14,000 feet in altitude; it is cut through toward the north by Grand River in its course out of Middle Park.

Park; station in Jefferson County on Colorado and Southern Railway; altitude, 6,462 feet.

Park; station in Park County on Colorado Midland Railway; altitude, 8,740 feet.

Park; town in Teller County on Colorado Springs and Cripple Creek District Railway.

Park Basin; valley in San Miguel County..... Telluride.

Park Cone; summit in Gunnison County; altitude, 12,021 feet.

Parkdale; village in Fremont County on Denver and Rio Grande Railroad; altitude, 5,788 feet ..... Canyon City.

Parker; post village in Douglas County on Colorado and Southern Railway; altitude, 5,861 feet..... Denver.

Park Range Forest Reserve; area 1,183 square miles.

Park View; peak in Larimer County; altitude, 12,433 feet.

Parkville; town in Saguache County.

Parlin; post village in Gunnison County, on the Denver and Rio Grande and the Colorado Midland railways; altitude, 7,942 feet.

Parma; station in Rio Grande County on Denver and Rio Grande Railroad; altitude, 7,604 feet.

Parrott; peak in La Plata Mountains, La Plata County; altitude, 11,876 feet..... La Plata.

Parrott; village in La Plata County; altitude, 8,633 feet..... La Plata.

Parry; peak in Front Range, Grand County; altitude, 13,133 feet.

Parson; gulch in San Juan County, tributary to South Fork Animas River..... Silverton.

Pass; butte on boundary between Routt and Rio Blanco counties.

Pass; creek in Grand County, a right-hand branch of Muddy Creek, tributary to Grand River.

Pass; creek in Gunnison County, a right-hand branch of Ohio *Creek, tributary to* Gunnison River..... Anthracite.

	Atlas sheet.
Pass; creek in Huerfano County, a right-hand branch of Huerfano River	Huerfano Park.
Pass; creek in Saguache County, a right-hand branch of Cochetopa Creek, tributary to Tomichi Creek.	
Pass; mountain in Puma Hills; altitude, 11,200 feet.	
Pasture; gulch in Montezuma County, tributary to East Dolores River	Rico.
Pat; canyon in Baca County, tributary to Cimarron River	Springfield.
Patterson; hollow in Otero County, tributary to Arkansas River	Timpas.
Pawnee; buttes in Weld County.	
Pawnee; pass in Weld County.	
Pawnee; post village in Morgan County.	
Paymaster; town in Ouray County.	
Payne; station in Delta County on Denver and Rio Grande Railroad; altitude, 5,279 feet.	
Peabody; station in Park County on Colorado and Southern Railway.	
Peach Blow; post village in Eagle County on Colorado Midland Railway; altitude, 7,087 feet.	
Pearl; creek in Eagle County, a right-hand branch of Eagle River	Leadville.
Pearl; hill in Eagle County	Tenmile District Special.
Pearl; mountain in Elk Mountains, on boundary between Pitkin and Gunnison counties; altitude, 13,484 feet	Crested Butte.
Pearl; pass in Elk Mountains, between Pitkin and Gunnison counties; altitude, 12,715 feet	Crested Butte.
Pearl; post village in Larimer County.	
Peck; gulch in Boulder County, tributary to Lefthand Creek	Boulder.
Peckham; post village in Weld County on Union Pacific Railroad; altitude, 4,727 feet	Greeley.
Pecks; creek in Pueblo County, a right-hand branch of Arkansas River	Pueblo.
Peconic; station in Kit Carson County on Chicago, Rock Island and Pacific Railway.	
Pedee; creek in Clear Creek County, a left-hand branch of Bear Creek, tributary to South Platte River	Georgetown.
Peeler; peak in Elk Mountains, Gunnison County; altitude, 12,219 feet	Anthracite.
Peeler Basin; valley in Gunnison County	Anthracite.
Pegasus; spring in Montezuma County; altitude, 5,650 feet.	
Pels; station in Las Animas County on Colorado and Southern Railway; altitude, 7,525 feet.	
Pemberton; town in Douglas County.	
Pendleton; mountain in Clear Creek County	Georgetown.
Penn Junction; station in Lake County on Denver and Rio Grande Railroad; altitude, 11,132 feet.	
Pennsylvania; gulch in Boulder County, tributary to Fourmile Creek	Boulder.
Pennsylvania; hill in Park County	Leadville.
Peoria; station in Arapahoe County on Union Pacific Railroad.	

Atlas sheet.

Perigo; post village in Gilpin County.

Perin; town in La Plata County.

Perrine; peak in San Juan Mountains, La Plata County..... Durango.

Perry Park; post village in Douglas County..... Castle Rock.

Peterhead; station in Jefferson County on Colorado and Southern Railway.

Petersburg; post village in Arapahoe County on Atchison, Topeka, and Santa Fe Railway; altitude, 5,307 feet..... Denver.

Peterson; canyon in Pueblo County, tributary to Mustang Creek ..... Apishapa.

Pewabic; mountain in Clear Creek County..... Idaho Springs Special.

Peyton; post village in Elbert County on Chicago, Rock Island and Pacific Railway; altitude, 6,789 feet.

Phelps; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.

Phillips; county in the northeastern part of the State; bounded on the north by Sedgwick County, on the east by Nebraska, on the south by Yuma County, and on the west by Logan County. The surface is a rolling plain, traversed east and west by the Burlington and Missouri River Railroad. The area is 677 square miles, of which 5 per cent, or 20,028 acres, were under cultivation in 1900. The population in 1900 was 1,583; and of Holyoke, the county seat, 451. In 1900 the average magnetic declination was 13° 20′ east. The mean annual rainfall is about 14 inches, and the mean annual temperature 50° to 55°.

Picayune; gulch in San Juan County, tributary to Animas River..... Silverton.

Piceance; creek in Rio Blanco County, a left-hand branch of White River.

Piceance; post village in Rio Blanco County on Colorado Midland Railway.

Pictou; post village in Huerfano County on Denver and Rio Grande Railroad ..... Walsenburg.

Piedmont; station in Ouray County on Denver and Rio Grande Railroad; altitude, 7,099 feet.

Piedmont Junction; station on Colorado and Wyoming Railway; altitude, 6,290 feet.

Piedra; creek in Rio Grande County, a right-hand branch of Rio Grande.

Piedra; post village in Archuleta County; altitude, 6,520 feet.

Piedra Parada; summit in Archuleta County; altitude, 8,200 feet.

Piedra Pintada; small creek in Rio Grande County, flowing into a sink.

Pieplant; post village in Gunnison County.

Pierce; gulch in Pueblo County, tributary to Beaver Creek... Pueblo.

Pierce; post village in Weld County on Union Pacific Railroad; altitude, 5,034 feet.

Pierson Basin; valley in Ouray County ..... Silverton.

Pigeon; peak in San Juan Mountains, La Plata County; altitude, *13,961 feet*..... Needle Mountains.

Atlas sheet.

Pikes; peak in Front Range, El Paso County, ascended by Manitou and Pikes Peak Railway; altitude, 14,107 feet ... Pikes Peak.

Pikes Peak Forest Reserve; area, 2,627 square miles.

Pikeview; post village in El Paso County on Denver and Rio Grande Railroad; altitude, 6,185 feet.

Pikeville; station in El Paso County on Denver and Rio Grande Railroad ..... Colorado Springs.

Pilot; town in Cheyenne County.

Pilot Knob; summit in San Juan Mountains on boundary between San Juan and San Miguel counties; altitude, 13,750 feet ..... Telluride.

Pine; creek in Douglas County, a left-hand branch of South Cherry Creek, tributary to Cherry Creek..... Denver.

Pine; creek in Fremont County, a right-hand branch of Arkansas River ..... Canyon City.

Pine; creek in Montezuma County, a left-hand branch of Lost Canyon Creek, tributary to Dolores River..... Rico.

Pine; creek in Pitkin County, a left-hand branch of Castle Creek, tributary to Roaring Fork..... Aspen.

Pine; post village in Jefferson County. Railroad name, Pine Grove.

Pine Creek; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,645 feet.

Pine Creek; station in Lake County on Denver and Rio Grande Railroad.

Pine Grove; station in Jefferson County on Colorado and Southern Railway; altitude, 6,749 feet. Post-office, Pine.. Platte Canyon.

Pine Ridge; station in La Plata County on Denver and Rio Grande Railroad; altitude, 7,255 feet.

Pine River; village in La Plata County; altitude, 7,034 feet.

Pinewood; post village in Larimer County.

Piney; creek in Eagle County, a right-hand branch of Eagle River..... Leadville.

Piney; river in Eagle County, a left-hand branch of Grand River.

Pinkerton Hot; springs in La Plata County..... Durango.

Pinkham; creek in Larimer County, a right-hand branch of North Platte River.

Pinkhampton; village in Larimer County; altitude, 8,000 feet.

Pinnacle; post village in Routt County.

Pinnacle Park; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Pinneo; station in Washington County on Burlington and Missouri River Railroad; altitude, 4,376 feet.

Piñon; canyon in Los Animas County, tributary to Purgatory River..... Higbee.

Piñon; mesa in Montezuma County; altitude, 6,269 feet.

Piñon; post village in Montrose County.

Piñon; ridge in Danforth Hills, Routt County.

Piñon; station in Pueblo County, on the Atchison, Topeka and Santa Fe, the Colorado and Southern, and the Denver and Rio Grande railroads; altitude, 5,026 feet. Post-office. Dawkins.

Atlas sheet.

Piñon; valley in Rio Blanco County.

Pinos; creek, a left-hand branch of Rio Conejos, tributary to Rio Grande.

Pisgah; station in Teller County on Colorado Midland Railway.

Pisgah, Mount; in Teller County; altitude, 10,322 feet..... Pikes Peak.

Pitkin; county in the west-central part of the State; bounded on the north by Garfield and Eagle counties, on the east by Sawatch Mountains, on the south by Gunnison County and Elk Mountains, and on the west by Mesa County. Its surface consists of high plateaus, which rise on the east to the Sawatch Range and on the south to Elk Mountains, forming the divide between Roaring Fork and Gunnison River. The area is 983 square miles, of which 2 per cent, or 12,583 acres, were under cultivation in 1900. The population in 1900 was 7,020; and of Aspen, the county seat, 3,303. In 1900 the average magnetic declination was 14° 30′ east. The mean annual rainfall is about 14 inches, and the mean annual temperature 40°.

Pitkin; post village in Gunnison County on Colorado and Southern Railway; population in 1900, 203; altitude, 9,190 feet.

Pittsburg; village in Gunnison County ..... Anthracite.

Placer; creek in Costilla County, a left-hand branch of Sangre de Cristo Creek, tributary to Trinchera River..... Huerfano Park.

Placer; station in Costilla County on Denver and Rio Grande Railroad..... Huerfano Park.

Placerville; post village in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,309 feet.

Placita; station in Pitkin County on Crystal River Railroad; altitude, 7,421 feet.

Plain; village in Summit County.

Plainview; station in Jefferson County on Denver, Northwestern and Pacific Railway ..... Blackhawk.

Plara, Mount; in Grand County.

Plateau; creek in Mesa and Delta counties, a left-hand branch of Grand River.

Plateau; creek in Montezuma County, a right-hand branch of Dolores River.

Plateau; peak on White River Plateau, Rio Blanco County; altitude, 12,030 feet.

Plateau; station in Douglas County on Denver and Rio Grande Railroad; altitude, 6,017 feet.

Plateau City; post village in Mesa County.

Platner; station in Washington County on Burlington and Missouri River Railroad; altitude, 4,443 feet.

Platoro; village in Conejos County.

Platte; mountain in Douglas County; altitude, 9,342 feet..... Platte Canyon.

Platte Canyon; station in Douglas County on Colorado and Southern Railway; altitude, 5,507 feet..... Platte Canyon.

Platte Pulpit; summit at the east of the canyon of South Platte River; altitude, 8,000 feet.

Atlas sheet.

Platte River; mountain in Front Range, forming the south wall of the canyon of North Fork South Platte River.

Platte River; station in Park County on Colorado and Southern Railway.

Platteville; post town in Weld County on Union Pacific Railroad; population in 1900, 263; altitude, 4,820 feet..... Greeley.

Pleasant; valley in Gilpin County..... Idaho Springs Special.

Pleasant; narrow valley on Arkansas River, between Sangre de Cristo Range and Arkansas Hills.

Pleasanton; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,469 feet. Post-office, Coaldale.

Pleasant Valley; village in Ouray County on Denver and Rio Grande Railroad; altitude, 6,271 feet.

Plum; canyon in Las Animas County, tributary to Purgatory River..... Mesa de Maya.

Plum; creek in Douglas County, a right-hand branch of South Platte River, heading in East and West Plum creeks..... Castle Rock.

Plum; creek in Prowers County, a right-hand branch of Arkansas River..... Albany.

Plumb; station in Boulder County on Burlington and Missouri River Railroad; altitude 4,943 feet.

Plumer; town in Ouray County.

Plymouth; village in Baca County..... Vilas.

Pocahontas; station in Garfield County on Colorado Midland Railway; altitude, 7,213 feet.

Pocono; station in Saguache County on Denver and Rio Grande Railroad; altitude, 10,306 feet.

Point Kara; hill in Phillips County.

Point Lookout; summit in Gunnison County..... Crested Butte.

Point Lookout; summit in Montezuma County; altitude, 8,439 feet.

Point Sublime; station in El Paso County on Colorado Springs and Cripple Creek District Railway. Post-office, Sublime.

Poison; canyon in Huerfano County, tributary to Huerfano River..... Huerfano Park.

Poison; creek in Eagle County, a right-hand branch of Grand River.

Poison Spring; gulch in Montrose and Delta counties, tributary to Smith Fork.

Poitrey; canyon in Las Animas County, tributary to Purgatory River..... Mesa de Maya.

Pole; creek in Grand County, a left-hand branch of Frazer River, tributary to Grand River.

Pole; creek in Hinsdale County, a left-hand branch of Henson Creek, tributary to Lake Fork Gunnison River..... Lake City.

Pole; creek in La Plata County, a left-hand branch of Canyon Creek, tributary to Animas River..... Needle Mountains.

Pole Creek; mountain in Hinsdale County; altitude, 13,400 feet.

Pollocks; village in Larimer County; altitude, 5,329 feet.

Atlas sheet.

Poncha; pass between the south end of Sawatch Range and the north end of Sangre de Cristo Range, connecting Arkansas Valley with the north end of San Luis Valley; altitude, 9,049 feet.

Poncha Junction; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,471 feet. Post-office, Poncha Springs.

Poncha Pass; station in pass of same name in Saguache County on Denver and Rio Grande Railroad; altitude, 9,049 feet.

Poncha Springs; post town in Chaffee County on Denver and Rio Grande Railroad; population in 1900, 97; altitude, 7,480 feet. Railroad name, Poncha Junction.

Pond; creek in El Paso and Lincoln counties, a right-hand branch of Horse Creek, tributary to Arkansas River. Sanborn. Catlin. Big Springs.

Pony; creek in Larimer County, a tributary to North Platte River.

Pony; creek in Routt County, a left-hand branch of Chimney Creek, tributary to Bear Creek.

Pony; gulch in Teller County, tributary to Oil Creek..... Pikes Peak.

Pomeroy; mountain in Chaffee County.

Pool; creek in Routt County, a left-hand branch of Yampa River.

Pool; post village in Routt County.

Popes Nose; summit in Saguache County; altitude, 12,274 feet.

Porcupine; creek in Garfield County, a left-hand branch of Grand River.

Porcupine; gulch in San Juan County, tributary to Animas River..... Silverton.

Porcupine; hill in Clear Creek County..... Georgetown.

Porphyry; gulch in San Juan County, tributary to Mineral Creek ..... Silverton.

Porphyry; mountain in Boulder County; altitude, 8,330 feet. Boulder.

Porphyry; mountain in Eagle County.

Porphyry Basin; valley in Hinsdale County..... Ouray.

Porter; post village in La Plata County on Denver and Rio Grande Railroad; altitude, 7,012 feet.

Portland; creek in Ouray County, a right-hand branch of Uncompahgre River..... Ouray.

Portland; post village in Fremont County on Atchison, Topeka and Santa Fe Railway; population in 1900, 69; altitude, 7,260 feet ..... Ouray.

Portland; station in Teller County, on the Colorado Springs and Cripple Creek District, the Midland Terminal, and the Florence and Cripple Creek railroads.

Poso; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,608 feet.

Potato; butte in Las Animas County..... Mount Carrizo.

Potato; gulch in Boulder County, tributary to Fourmile Creek. Boulder.

Potato; hill in San Juan County; altitude, 11,866 feet..... Engineer Mountain.

Pot Hole; valley in Rio Blanco County.

Atlas sheet.

Potosi; peak in San Juan Mountains, Ouray County; altitude, 13,763 feet ..... Silverton.
Potter; creek in Montrose County, a left-hand branch of Gunnison River.
Poughkeepsie; gulch in San Juan County, tributary to Uncompahgre River ..... Silverton.
Poverty; gulch in Gunnison County, tributary to Slate River. Anthracite.
Poverty; gulch in San Miguel County, tributary to East Dolores River ..... Telluride.
Poverty; gulch in Teller County ..... Cripple Creek Special.
Powder; station in Pitkin County on Denver and Rio Grande Railroad.
Powderhorn; post village in Gunnison County; altitude, 7,970 feet.
Powell; arroyo in Pueblo County, east of Apishapa River .... Apishapa.
Powell; station in Logan County on Union Pacific Railroad.
Powell; village in Las Animas County ..... Spanish Peaks.
Powell, Mount; in Park Range, Summit County; altitude, 13,398 feet.
Powell Park; valley in Rio Blanco and Routt counties on White River; altitude, 6,000 feet.
Power; station in San Juan County on Silverton and Northern Railroad.
Powers; town in Dolores County.
Price; village in Archuleta County on Denver and Rio Grande Railroad.
Priest; gulch in Montezuma County, tributary to East Dolores River ..... Rico.
Primero; post village in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 6,903 feet.
Primero Junction; station in Las Animas County on Colorado and Wyoming Railway; altitude, 6,654 feet.
Prince Reservoir; artificial lake in Kiowa County; altitude, 3,850 feet ..... Lamar.
Princeton; station in Chaffee County on Colorado Midland Railway; altitude, 8,249 feet.
Princeton, Mount; in Sawatch Range, Chaffee County; altitude, 14,196 feet.
Pring; station in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 6,780 feet.
Proctor; station in Logan County on Union Pacific Railroad.
Promontory; plateau in Routt County.
Prospect; creek in San Miguel County, a left-hand branch of San Miguel River ..... Telluride.
Prospect; gulch in San Juan County, tributary to Cement Creek ..... Silverton.
Prospect; hill in Phillips County; altitude, 8,893 feet.
Prospect; hill in Weld County ..... Greeley.
Prospect; mountain in Lake County; altitude, 12,618 feet.... Leadville.
Prospect; peak in Conejos County; altitude, 9,837 feet.
Prospect Point; summit in Gunnison County ..... Anthracite.

Atlas sheet.

Prosser; gulch in Gilpin County, tributary to North Clear Creek. Central City Special.

Providence; town in Gunnison County.

Prowers; county in the southeastern part of the State; bounded on the north by Kiowa County, on the east by Kansas, on the south by Baca County, and on the west by Bent County. Its surface consists of rolling plains and is traversed east and west by Arkansas River, and by Atchison, Topeka and Santa Fe Railway. The area is 1,602 square miles, of which 5 per cent, or 58,172 acres, were under cultivation in 1900. The population in 1900 was 3,766; and of Lamar, the county seat, 987. In 1900 the average magnetic declination was 12° 20′ east. The mean annual rainfall is about 15 inches, and the mean annual temperature 50° to 55°.

Prowers; post village in Bent County on Atchison, Topeka and Santa Fe Railway; altitude, 3,678 feet..... Lamar.

Pruden; village in Saguache County.

Pryor; post village in Huerfano County on Denver and Rio Grande Railroad.

Ptarmigan; hill in Eagle County; altitude, 12,174 feet..... Tenmile District Special.

Ptarmigan; peak in Park Range, between Park and Lake counties; altitude, 13,746 feet..... Leadville.

Pueblo; county in the southeastern portion of the State; bounded on the north by El Paso County, on the east by Otero County, on the south by Huerfano and Las Animas counties, and on the west by Fremont and Custer counties. The surface consists of rolling plains traversed east and west by Arkansas River and by Missouri Pacific Railway, and north and south by the Colorado and Southern and the Denver and Rio Grande railroads. The area is 2,447 square miles, of which nearly 3 per cent, or 40,821 acres, were under cultivation in 1900. The population in 1900 was 34,448; and of Pueblo, the county seat, 28,157. In 1900 the average magnetic declination was 13° 10′ east. The mean annual rainfall is about 12 inches, and the mean annual temperature 40° to 50°.

Pueblo; county seat of Pueblo County, entered by five railroads. It lies on both sides of Arkansas River, and has many smelters; altitude, 4,675 feet ..... Pueblo.

Pueblo Junction; station in Pueblo County, on the Atchison, Topeka and Santa Fe, and the Colorado and Southern railways; altitude, 4,669 feet.

Pullen; village in Larimer County.

Pullman; station in Denver County on Union Pacific Railroad; altitude, 5,193 feet. Post-office, Elyria.

Pultney; station in Pueblo County on Missouri Pacific Railway; altitude, 4,381 feet.

Puma; hills in Park County, a part of Tarryall Mountains.

Pumpkin; hollow in Pueblo County, tributary to Turkey Creek ..... Pueblo.

Puncha; creek, a right-hand branch of South Arkansas River, tributary to Arkansas River.

Punch Bowl; summit in Fremont County.

Atlas sheet.

Purgatory; peak in Sangre de Cristo Range, Las Animas County; altitude, 13,749 feet.

Purgatory; river, a right-hand branch of Arkansas River, heading in Sangre de Cristo Range, near the southern boundary of the State, flowing in a general northeasterly course to its mouth near Las Animas.

Purple; peak in Elk Mountains, Gunnison County.

Putnam Basin; valley in San Juan County.

Puzzle; station in Summit County on Colorado and Southern Railway.

Puzzler; station in Boulder County on Colorado and Northwestern Railroad; altitude, 8,699 feet.

Pyke; town in Saguache County.

Pyramid; peak in Elk Mountains, Pitkin County; altitude, 13,885 feet.

Pyramid; post village in Rio Blanco County.

Quaking Aspen; creek in Eagle County, a left-hand branch of Grand River.

Quandary; creek in Summit County, a left-hand branch of Blue River, tributary to Grand River ..... Leadville.

Quandary; peak in Park Range, Summit County; altitude, 14,266 feet ..... Leadville.

Quarry; post village in Montezuma County on Denver and Rio Grande Railroad ..... Rico.

Quartz; hill in Gilpin County ..... Central City Special.

Quartz; station in Gunnison County on Colorado and Southern Railway; altitude, 9,642 feet.

Quartz; valley in Gilpin County ..... Central City Special.

Quartzite; group in the highest and most rugged part of the San Juan Mountains, so named because composed of quartzite.

Queen Basin; valley in Gunnison County ..... Crested Butte.

Queen of the West; station in Summit County on Denver and Rio Grande Railroad.

Queens Chair, The; summit in Gilpin County; altitude, 8,750 feet ..... Central City Special.

Querida; post village in Custer County ..... Canyon City.

Quimby; station in Arapahoe County on Denver and Rio Grande Railroad.

Quinns; station in Pitkin County on Colorado Midland Railway.

Rabbit; creek in Larimer County, a right-hand branch of Cache la Poudre River.

Rabbit; hills in Rio Blanco County.

Rabbit; mountain in Boulder County; altitude, 6,015 feet .... Niwot.

Rabbit Ears; mountain in Routt County; altitude, 10,719 feet.

Radiant; post village in Fremont County.

Ragans; station in Gunnison County on Denver and Rio Grande Railroad.

Ragged; mountain in Elk Mountains, Gunnison County; altitude, 12,481 feet.

Ralston; butte in Boulder County; altitude, 10,593 feet.

Atlas sheet.

Ralston; creek in Jefferson County, a left-hand branch of Clear Creek, tributary to South Platte River ..... Denver.
Ralston; peak in Jefferson County ..... Denver.
Ralston; station in Jefferson County on Union Pacific Railroad; altitude, 5,695 feet ..... Denver.
Ralston Junction; station in Jefferson County on Denver, Lakewood and Golden Railroad.
Ramah; post village in Elbert County on Chicago, Rock Island and Pacific Railway; altitude, 6,093 feet.
Rampart; range, a part of Front Range, extending from South Platte River to Fountain Creek.
Ramshorn; ridge in Ouray County ..... Ouray
Ranche; creek, right-hand branch of Frazer River, tributary to Grand River.
Rand; post village in Larimer County.
Rangely; post village in Rio Blanco County.
Rarick; gulch in Gunnison County, tributary to Spring Creek. Crested Butte.
Raspberry; butte in Douglas County ..... Castle Rock.
Raspberry; creek in Rio Blanco County, a right-hand branch of South Fork White River.
Raspberry; mountain in Teller County; altitude, 10,500 feet.. Pikes Peak.
Raspberry Fork; in Larimer County, a left-hand branch of North Platte River.
Rathbone; station in Pitkin County on Colorado Midland Railroad; altitude, 7,496 feet.
Raton; canyon in Las Animas County, tributary to Purgatory River ..... Elmoro.
Raton; creek in Rio Grande County, a right-hand branch of Rio Grande.
Raton; mesa in Las Animas County ..... Elmoro.
Rattlesnake; gulch in Boulder County, tributary to South Boulder Creek ..... Blackhawk.
Rattlesnake Park; in Larimer County.
Raven; hill in Teller County ..... Cripple Creek Special.
Raven; post village in Garfield County.
Raven; ridge in Rio Blanco County, extending into Utah.
Raven Park; valley in Rio Blanco County.
Raymer; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,779 feet.
Raymond; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,349 feet.
Razor; creek in Saguache County a right-hand branch of Tomichi Creek, tributary to Gunnison River.
Read; post village in Delta County.
Recen; village in Summit County ..... Leadville.
Red; canyon in Baca County, tributary to Cimarron River ... Springfield.
Red; creek in Gunnison County, a right-hand branch of Gunnison River.
Red; creek in Ouray County, a right-hand branch of Red Mountain Creek, tributary to Uncompahgre River ..... Silverton.
Red; creek in Fremont and Pueblo counties, a right-hand *branch of* Arkansas River ..... Pueblo.

Atlas sheet.

Red; gorge in Grand County, tributary to Grand River.
Red; hill in Boulder County; altitude, 6,574 feet ..... Boulder.
Red; hill in La Plata County ..... Durango.
Red; hill in Teller County ..... Cripple Creek Special.
Red; mountain in Gunnison County.
Red; mountain in San Juan Mountains, Hinsdale County; altitude, 12,800 feet ..... San Cristobal.
Red; mountain in Pitkin County ..... Aspen.
Red; peak in Eagle County; altitude, 12,382 feet.
Red; ridge in Teller and Fremont counties ..... Pikes Peak.
Red No. 3; summit in San Juan Mountains, on boundary between Ouray and San Juan counties; altitude, 12,865 feet ..... Silverton.
Red and white; mountain in Gore Mountains, Eagle County.
Red Canyon; station in Garfield county on Denver and Rio Grande Railroad.
Redcliff; post town and county seat of Eagle County on Denver and Rio Grande Railroad; population in 1900, 256; altitude, 8,598 feet.
Redcloud; gulch in Hinsdale County, tributary to Henson Creek ..... Silverton.
Red Cloud; peak in Hinsdale County; altitude 14,050 feet .... San Cristobal.
Red Dirt; creek in Eagle County, a right-hand branch of Grand River.
Red Hill; gulch in Boulder County, a right-hand branch of South St. Vrain Creek, tributary to St. Vrain Creek ..... Boulder.
Red Hill; station in Park County; altitude, 9,527 feet.
Red Lion; station in Logan County on Union Pacific Railroad.
Red Mountain; creek in Ouray County, a left-hand branch of Uncompahgre River ..... Silverton.
Red Mountain; gulch in Hinsdale County, tributary to Lake Fork Gunnison River ..... San Cristobal.
Red Mountain; post town in Ouray County on Silverton Railroad; population in 1900, 30 ..... Silverton.
Red Rio Grande; a right-hand branch of Conejos Creek.
Red Rock; canyon in Las Animas County, tributary to Purgatory River ..... Timpas.
Red Rock; peak in Routt County.
Red Rock; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,688 feet.
Red Rock Basin; valley in Routt County.
Red Sandstone; creek in Eagle County, a right-hand branch of Gores Creek, tributary to Eagle River.
Red Stone; creek in Larimer County, a left-hand branch of Buckhorn Creek, tributary to Thompson Creek.
Redstone; post village in Pitkin County on Denver and Rio Grande Railroad.
Redstone Junction; station on Crystal River Railroad; altitude, 7,202 feet.
Red Table; mountain in Eagle County; altitude, 11,600 feet.
Redwell Basin; valley in Gunnison County ..... Anthracite.
Regnier; post village in Baca County.

Atlas sheet.

Reilley; canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.
Reilly; butte in Jefferson County.
Remine; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.
Reno; station in Fremont County on Denver and Rio Grande Railroad; altitude, 5,233 feet.
Reno; station in Phillips County on Burlington and Missouri River Railroad.
Republican; mountain in Front Range, Clear Creek County; altitude, 12,393 feet ..... Georgetown.
Republican; river, a large branch of Kansas River, heading in North and South forks.
Reservoir; lakes in Montezuma County.
Resolis; post village in Elbert County on Chicago, Rock Island and Pacific Railway; altitude, 5,576 feet ..... Limon.
Resolution; creek in Eagle County, a right-hand branch of Eagle River ..... Leadville.
Resurrection; town in Lake County.
Retreat; creek in Larimer County, a right-hand branch of North Platte River.
Rhone; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,522 feet.
Rhyolite; peak in Teller County; altitude, 10,775 feet ..... Pikes Peak.
Rices; station in Dolores County on Denver and Rio Grande Railroad; altitude, 10,048 feet.
Richards; town in Park County.
Richmond; hill in Pitkin County ..... Aspen.
Richmond; mountain in Elk Mountains, Gunnison County; altitude, 12,543 feet ..... Anthracite.
Richmond Basin; valley in Ouray County ..... Silverton.
Richthofen, Mount; in Larimer County.
Rico; county seat of Dolores County on Denver and Rio Grande Railroad; population in 1900, 811; altitude, 8,725 feet.
Ridge; summit in La Plata County; altitude, 7,714 feet ..... Durango.
Ridgeway; post town in Ouray County on Denver and Rio Grande Railroad; population in 1900, 245; altitude, 6,993 feet. Railroad name, Ridgeway Junction.
Rifle; creek in Garfield County, a right-hand branch of Grand River, originating in East and Middle forks.
Rifle; post town in Garfield County on the Denver and Rio Grande and the Colorado Midland railways; population in 1900, 273; altitude, 5,300 feet.
Rincones; village in Conejos County.
Rinn; post village in Weld County.
Rio Alamoso; river in Rio Grande and Conejos counties, a right-hand branch of Rio Grande.
Rio Alma; river in Mineral County, a right-hand branch of Rio Grande.
Rio Alma; river in Saguache County, a left-hand branch of Saguache River.

Atlas sheet.

Rio Blanco; county in the northwestern part of the State; bounded on the north by Routt County, on the east by Routt and Garfield counties, on the south by Garfield County, and on the west by Utah. Its surface consists mostly of plateaus, sloping toward the valley of White River, which centrally traverses the county from east to west. Its area is 3,249 square miles, of which 1 per cent, or 21,846 acres, were under cultivation in 1900. The population in 1900 was 1,690; and of Meeker, the county seat, 507. In 1900 the average magnetic declination was for the eastern part, 14° 20′ east, and for the western part, 15° 00′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 40° to 45°.

Rio Blanco; river in Archuleta County, a left-hand branch of San Juan River.

Rio Blanco; post village in Rio Blanco County.

Rio Chama; river in Conejos County, a left-hand branch of Rio Grande.

Rio Conejos; river in Conejos County, a right-hand branch of Rio Grande.

Rio Culebra; river in Costilla County, a left-hand branch of Rio Grande.

Rio del Codo; river in San Miguel County, a right-hand branch of San Miguel River.

Rio de los Piños; river in La Plata County, a right-hand branch of San Juan River.

Rio Dolores Chiquita; river in Mesa County, a right-hand branch of Dolores River.

Rio Dominguez; river in Mesa County, a left-hand branch of Uncompahgre River.

Rio Escalante; river in Montrose County, a left-hand branch of Gunnison River.

Rio Grande; county in the southern part of the State; bounded on the north by Saguache County, on the east by Saguache, Costilla, and Conejos counties, on the south by Conejos County, and on the west by Mineral county. It includes part of San Luis Valley, and extends on the west into San Juan Mountains. Its area is 1,331 square miles, of which 9 per cent, or 78,141 acres, were under cultivation in 1900. The population in 1900 was 4,080; and of Del Norte, the county seat, 705. In 1900 the average magnetic declination was 13° 00′ east. The mean annual rainfall is about 7 inches, and the mean annual temperature 40°.

Rio Grande; one of the large rivers of the United States. It heads in San Juan Mountains, near Bakers Park, flows east to the San Luis Valley, then turns south, traversing the entire Territory of New Mexico to El Paso, Tex., beyond which point it forms the boundary between the United States and Mexico. Discharge at Del Norte, April 1 to October 31, 1904, 345,900 acre-feet.

Rio Grande; village in Conejos County.

Atlas sheet.

Rio Grande and Pagosa Springs Railroad; line extending from Lumberton, N. Mex., to Blanco, Colo., a distance of 30 miles.

Rio Grande Pyramid; summit in San Juan Mountains, Hinsdale County; altitude, 13,773 feet.

Rio Lado; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 8,073 feet ..... Rico.

Rio la Jara; river in Conejos County, a right-hand branch of Rio Grande.

Rio Mancos; river in Montezuma County, a right-hand branch of San Juan River, originating in North, Middle, and East forks.

Rio Navajo; river in Archuleta County, a left-hand branch of San Juan River.

Rio Nutria; river in Archuleta County, a left-hand branch of Rio Piedra.

Rio Piedra; river in Mineral, Hinsdale, and Archuleta counties, a right-hand branch of San Juan River.

Rio San Antonio; river in Conejos County, a right-hand branch of Rio Conejos, tributary to Rio Grande.

Rio Ventero; river in Costilla County, a left-hand branch of Rio Culebra, tributary to Rio Grande.

Ritchie; gulch in Fremont County, a right-hand branch of Arkansas River ..... Pueblo.

Rito; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,679 feet.

Rito Agua Dulce; creek in Las Animas County, a right-hand branch of Purgatory River ..... Elmoro.

Rito Alto; peak in Sangre de Cristo Range, Custer County; altitude, 12,989 feet.

Rito Azul; creek in Las Animas County, a left-hand branch of Trinchera Creek, tributary to Purgatory River ..... Elmoro.

Rito el Cato; creek in Archuleta County, a right-hand branch of San Juan River.

Rito Seco; creek in Las Animas County, a right-hand branch of Purgatory River ..... Elmoro.

Rivera; station in Las Animas County on Colorado and Southern Railway.

River Bend; post village in Elbert County on Union Pacific Railroad; altitude, 5,492 feet ..... Limon.

Riverdale; station in Bent County on Atchison, Topeka and Santa Fe Railway; altitude, 3,936 feet.

Riverside; post village in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,364 feet.

Riverton; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,800 feet.

Road; canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.

Road Cap; creek in Delta County, a right-hand branch of North Fork Gunnison River.

Roan; creek in Garfield and Mesa counties, a left-hand branch of Grand River.

Atlas sheet.

Roan or Book; plateau in the western part of the State, sloping gently northward to the canyon of White River and breaking off precipitously to the south to the desert valley of the Grand. The average elevation of the crest is 8,000 feet.

Roaring Fork; creek in Garfield and Pitkin counties, a left-hand branch of Grand River ..... Aspen.

Roaring Fork; creek in Larimer County, a left-hand branch of Raspberry Fork, tributary to North Platte River.

Roaring Forks; creek in Montezuma County, a left-hand branch of East Dolores River ..... Rico.

Roaring Judy; creek in Gunnison County, a left-hand branch of East River ..... Crested Butte.

Roax; canyon in Las Animas County, tributary to Purgatory River ..... Timpas.

Robb; station in Yuma County on Burlington and Missouri River Railroad; altitude, 3,749 feet.

Robin; station in San Juan County on Silverton Northern Railroad.

Robinson; gulch in Clear Creek and Jefferson counties, tributary to Clear Creek ..... Blackhawk.

Robinson; station in Bent County on Atchison, Topeka and Santa Fe Railway: altitude, 3,986 feet.

Robinson; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,007 feet ..... Las Animas.

Robinson; post village in Summit County on Denver and Rio Grande Railroad; altitude, 10,857 feet ..... Leadville.

Robinson Basin; valley in Gunnison County ..... Anthracite.

Roc; creek in Montrose County, a left-hand branch of Dolores River.

Roche Moutonnée; creek in Eagle County, a left-hand branch of Eagle River ..... Leadville.

Rock; creek in Boulder County, a right-hand branch of Coal Creek, tributary to South Platte River ..... Denver.

Rock; creek in Gunnison County, a left-hand branch of Roaring Creek, tributary to Grand River.

Rock; creek in Montrose County, a left-hand branch of Dolores River.

Rock; creek in Park County, a left-hand branch of Tarryall Creek, tributary to South Platte River.

Rock; creek in Pitkin County, a left-hand branch of Roaring Fork.

Rock; creek in Pueblo County, a right-hand branch of Arkansas River ..... Pueblo.

Rock; creek in Rio Grande County, a left-hand branch of Piedra Creek, tributary to Rio Grande.

Rock; creek in Routt County, a right-hand branch of Grand River.

Rock; lake in Boulder County ..... Boulder.

Rock Cliff; village in Saguache County; altitude, 8,270 feet.

Rock Creek; station in Eagle County on Denver and Rio Grande Railroad; altitude, 8,292 feet. Post-office, Gilman.

Atlas sheet.

Rockland; village in Logan County.

Rockvale; post city in Fremont County on Atchison, Topeka and Santa Fe Railway; population in 1900, 870; altitude, 5,440 feet ..... Canyon City.

Rockwood; post village in La Plata County on Denver and Rio Grande Railroad; altitude, 7,355 feet ..... Durango.

Rocky; canyon in Arapahoe County, tributary to Arikaree River.

Rocky; gulch in San Juan County, tributary to Cunningham Creek ..... Silverton.

Rocky; village in Park County ..... Pikes Peak.

Rocky Ford; post town in Otero County on Atchison, Topeka and Santa Fe Railway; population in 1900, 2,018; altitude, 4,176 feet ..... Catlin.

Rocky Point; summit in Lincoln County ..... Sanborn.

Roeder; creek in Clear Creek County, a right-hand branch of Bear Creek, tributary to Turkey Creek.

Roger; gulch in San Miguel County, tributary to San Miguel River ..... Telluride.

Rogers; station in Gunnison County on Denver and Rio Grande Railroad.

Rogers Mesa; station in Delta County on Denver and Rio Grande Railroad; altitude, 5,433 feet.

Roggen; post village in Morgan County on Burlington and Missouri River Railroad; altitude, 4,718 feet.

Rolling; mountain in San Juan Mountains, San Juan County; altitude, 13,694 feet ..... Telluride.

Rollinsville; post village in Gilpin County, on Denver, Northwestern and Pacific Railway; altitude, 8,323 feet ..... Blackhawk.

Romeo; post village in Conejos County.

Romley; station in Chaffee County on Colorado and Southern Railway; altitude, 10,532 feet.

Root; creek in La Plata County, a right-hand branch of La Plata River ..... La Plata.

Rosa, Mount; in Front Range, El Paso County; altitude, 11,427 feet ..... Colorado Springs.

Rosalie, Mount; in Front Range, Park County; altitude, 13,575 feet ..... Georgetown.

Roscoe; village in Jefferson County on Colorado and Southern Railway ..... Blackhawk.

Rose; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River ..... Georgetown.

Rose; gulch in Clear Creek County, tributary to Clear Creek .. Idaho Springs Special.

Rose; station in Pitkin County on Denver and Rio Grande Railroad.

Rosemont; post village in Teller County on Colorado Springs and Cripple Creek District Railway; altitude, 9,799 feet.

Rosita; creek in Custer County, a right-hand branch of Grape Creek, tributary to Arkansas River ..... Canyon City.

Rosita; post town in Custer County; population in 1900, 110; altitude, 8,932 feet.

Ross; *spring in* Pueblo County ..... Nepesta.

Atlas sheet.

Ross Basin; valley in San Juan County..... Silverton.

Roswell; post village in El Paso County, on the Denver and Rio Grande, and the Chicago, Rock Island and Pacific railways; altitude, 6,073 feet. Railroad name, Johnson..... Colorado Springs.

Roubideau; creek in Delta County, a right-hand branch of Gunnison River.

Roubideau; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,894 feet.

Rouge; canyon in Grand County, tributary to Grand River.

Rough and Tumbling; creek in Park County, a right-hand branch of South Fork South Platte River ..... Leadville.

Round; butte in Larimer County.

Round; hill in Park County..... Leadville.

Round; mountain in Custer County; altitude, 8,722 feet..... Canyon City.

Round; mountain in Elk Mountains, Gunnison County; altitude, 10,881 feet..... Crested Butte.

Round; mountain in San Juan Mountains, San Juan County; altitude, 13,422 feet ..... Silverton.

Round Hill; station in Saguache County on Denver and Rio Grande Railroad; altitude, 8,677 feet. Post-office, Alder.

Rouse; post village in Huerfano County on Colorado and Southern Railway..... Walsenburg.

Rouse Junction; station in Huerfano County on a spur of Denver and Rio Grande Railroad; altitude, 6,136 feet..... Walsenburg.

Routt; county in the extreme northwestern part of the State; bounded on the north by Wyoming, on the east by Park Range, on the south by Eagle and Rio Blanco counties, and on the west by Utah. The surface consists of broad plateaus rising eastward to Park Range. The area is 6,980 square miles, of which 1 per cent, or 53,977 acres, were under cultivation in 1900. The population in 1900 was 3,661; and of Hahns Peak, the county seat, 46. In 1900 the average magnetic declination was 14° 40′ east. The mean annual rainfall is about 12 inches, and the mean annual temperature 40° to 50°.

Routt; gulch in Boulder County, tributary to Fourmile Creek. Boulder.

Routt; village in Routt County.

Rowe; village in Prowers County.

Rowena; post village in Boulder County; altitude, 7,177 feet.. Boulder.

Rowtner, Mount; in the Gunnison country; altitude, 13,750 feet.

Roy; station in Lake County on Denver and Rio Grande Railroad; altitude, 10,838 feet.

Royal; gorge in Fremont County, in the Grand Canyon of the Arkansas ..... Canyon City.

Royal; gulch in San Miguel County, tributary to San Miguel River..... Telluride.

Ruby; creek in Clear Creek County, a left-hand branch of Vance Creek, tributary to South Platte River..... Georgetown.

Ruby; creek in San Juan and La Plata counties, a left-hand branch of Animas River..... Needle Mountains.

Atlas sheet.

Ruby; peak in Elk Mountains, Gunnison County; altitude, 12,749 feet ..... Anthracite.

Ruby; range in Gunnison County ..... Anthracite.

Ruby; station in Mesa County on Rio Grande Western Railway; altitude, 4,405 feet.

Ruby; station in Gunnison County on Denver and Rio Grande Railroad. Post-office, Floresta ..... Anthracite.

Ruedi; post village in Eagle County on Colorado Midland Railway; altitude, 7,568 feet.

Ruffner; mountain in San Miguel County ..... Telluride.

Rugby; post village in Las Animas County on Colorado and Southern Railway.

Rugby; station in Huerfano County on Colorado and Southern Railway. Railroad name, Kepner.

Rule; creek in Bent County, a right-hand branch of Arkansas River. Higbee. Las Animas.

Running; creek in Elbert County, a left-hand branch of Box-elder Creek, tributary to South Platte River ..... Castle Rock. East Denver.

Rush; creek in Kiowa, Cheyenne, and Lincoln counties, a right-hand branch of Big Sandy Creek, tributary to Arkansas River.

Rush; creek in Pueblo County, a right-hand branch of Arkansas River ..... Pueblo.

Rush Basin; valley in Montezuma County ..... La Plata.

Russell; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.

Russell; post village in Costilla County.

Russell; spring in Saguache County.

Russell Gulch; post village in Gilpin County; altitude, 8,105 feet ..... Central City Special.

Rust; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,012 feet.

Rustic; village in Larimer County.

Ruxton; creek in El Paso County, a small right-hand branch of Fountain Creek, tributary to Arkansas River ..... Colorado Springs.

Ryan; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Rye; post village in Pueblo County ..... Walsenburg.

Ryman; creek in Montezuma County, a left-hand branch of East Dolores River ..... Rico.

Sabeta; peak in Sawatch Range, Saguache County.

Sable; station in Adams County on Union Pacific Railway.

Saco; station in Pitkin County on Denver and Rio Grande Railroad.

Sacramento; gulch in Park County, tributary to South Platte River ..... Leadville.

Sachett; mountain in El Paso County ..... Pikes Peak.

Saddle; mountain in Montrose County.

Saddle; mountain in Park County; altitude, 10,815 feet ..... Pikes Peak.

Saderlind; station in Teller County on Colorado Springs and Cripple Creek District Railway; altitude, 9,943 feet.

Sage; creek in Larimer County, a left-hand branch of Yampa *River.*

Atlas sheet.

Sage; plateau in Routt County.

Saguache; county in the south-central part of the State; bounded on the north by Gunnison, Chaffee, and Fremont counties, on the east by Fremont, Custer, and Huerfano counties, and on the south by Costilla and Rio Grande counties, and on the west by Hinsdale and Gunnison counties. It includes the northern part of San Luis Valley, extending on the east to the slopes of Sangre de Cristo Range, and on the west over the Cochetopa Hills to the rolling country sloping to the valley of Gunnison River. Its area is 2,769 square miles, of which 7 per cent, or 119,587 acres, were under cultivation in 1900. The population in 1900 was 3,853; and of Saguache, the county seat, 389. In 1900 the average magnetic declination was 12° 55′ east. The mean annual rainfall is about 7 inches, and the mean annual temperature 40°.

Saguache; post town and county seat of Saguache County; population in 1900, 389; altitude, 7,745 feet.

Saguache; river heading in Cochetopa Hills and flowing south into San Luis Valley, where it disappears.

St. Charles; canyon in Pueblo County, a right-hand branch of St. Charles River ..... Pueblo.

St. Charles; river in Pueblo County, a right-hand branch of Arkansas River. Pueblo. Nepesta.

St. Charles; station in Pueblo County, on Denver and Rio Grande Railroad; altitude, 4,888 feet.

St. Cloud; post village in Larimer County.

St. Elmo; post town in Chaffee County on Colorado and Southern Railway; population in 1900, 64; altitude, 10,051 feet.

St. Kevin; station in Lake County on Denver and Rio Grande Railroad; altitude, 9,804 feet.

St. Lewis; creek in Grand County, a left-hand branch of Frazer River, tributary to Grand River.

St. Mary; post village in Huerfano County; altitude, 6,067 feet.

St. Peters; station in El Paso County on Colorado Springs and Cripple Creek District Railway; altitude, 8,701 feet.

St. Sophia; ridge on boundary between Ouray and San Miguel counties ..... Telluride.

St. Thomas; town in Teller County on Florence and Cripple Creek Railroad.

St. Vrain; creek in Weld County, a left-hand branch of South Platte River. Niwot. Greeley.

St. Vrains; town in Weld County; altitude, 5,120 feet.

Salado; creek in Las Animas County, a left-hand branch of Apishapa River ..... Elmoro.

Salem; post village in Arapahoe County.

Salida; city in Chaffee County on Denver and Rio Grande Railroad; population in 1900, 3,722; altitude, 7,038 feet.

Salina; post village in Boulder County on Colorado and Northwestern Railroad; altitude, 6,571 feet.

Salina; station in Park County on Colorado Midland Railway; altitude, 8,936 feet.

Salis; station on Union Pacific Railroad; altitude, 4,123 feet.

Atlas sheet.

Salls; station in Cheyenne County on Union Pacific Railroad.
Salt; canyon in Pueblo County, tributary to Beaver Creek.... Pueblo.
Salt; creek in Mesa County, a left-hand branch of Plateau Creek.
Salt; creek in Pueblo County, a right-hand branch of Arkansas River..... Pueblo.
Salt; creek in Pueblo County, a right-hand branch of St. Charles River ..... Walsenburg.
Salt; lake in Park County.
Salt Creek; post village in Pueblo County on Denver and Rio Grande Railroad; altitude 5,457 feet.
Samboul; gulch in La Plata County, tributary to Flagler Fork. Durango.
Sample; station in Fremont County on Denver and Rio Grande Railroad.
Sampler; village in Teller County.
Sams; post village in San Miguel County on Denver and Rio Grande Railroad.
San Acacia; village in Costilla County.
San Bernardo; mountain in San Juan Mountains, San Miguel County; altitude, 11,845 feet..... Telluride.
San Bernardo; post village in San Miguel County on Denver and Rio Grande Railroad; altitude, 9,465 feet ..... Telluride.
Sanborn; post village in Lincoln County..... Sanborn.
San Cristobal; lake in Hinsdale County; altitude, 9,000 feet. San Cristobal.
Sand; arroyo in Baca and Las Animas counties, a right-hand branch of Adobe Creek, tributary to Arkansas River.
Sand; canyon in Baca County, tributary to Cimarron River... Springfield.
Sand; creek in Arapahoe and Adams counties, a left-hand branch of South Platte River..... Denver.
Sand; creek in Routt County, a left-hand branch of Williams River.
Sand; creek in Weld County, a left-hand branch of Cache la Poudre River ..... Greeley.
Sand; hills extending across the western part of Baca County. Vilas.
Sand; hills in Lincoln County ..... Arroyo.
Sand Creek; station in Denver County on Union Pacific Railroad.
Sandford; post village in Conejos County.
Sand Spur; station in Weld County on Union Pacific Railroad.
San Francisco; creek in Las Animas County, a right-hand branch of Purgatory River, tributary to Arkansas River... Elmoro.
San Francisco; creek in Rio Grande County, a right-hand branch of Rio Grande.
San Francisco; pass in Sangre de Cristo Mountains, Las Animas County; altitude, 8,560 feet.
San Francisco; valley at the head of South Fork Purgatory River.
San Francisco; village in Costilla County.
San Francisco; small village in Las Animas County ..... Spanish Peaks.
Sangre de Cristo; creek in Costilla County, a left-hand branch *of Trinchera* River, tributary to Rio Grande..... Huerfano Park.

Atlas sheet.

Sangre de Cristo; mountains, a long, narrow range stretching from the head of San Luis Valley along its eastern border to New Mexico, including several peaks exceeding 14,000 feet in altitude.

Sangre de Cristo; pass in Sangre de Cristo Range; altitude, 9,454 feet.

San Isabel; creek in Saguache County, a left-hand branch of San Luis Creek.

San Isabel; post village in Saguache County; altitude, 7,537 feet.

San Isabel Forest Reserve; area, 501 square miles.

San Isidro; creek in Las Animas County, a right-hand branch of Purgatory River..... Elmoro.

San Joaquin; ridge in San Miguel County ..... Telluride.

San Juan; county in the southwestern part of the State; bounded on the north, east, and west by San Juan Mountains and on the south by La Plata County. Its surface is mountainous, including some of the highest spurs of the San Juan group. The southern part is Bakers Park, a valley hemmed in by mountains. Its area is 438 square miles, practically none of which is cultivated. The population in 1900 was 2,342; and of Silverton, the county seat, 1,360. In 1900 the average magnetic declination was 12° 50′ east. The mean annual rainfall is about 19 inches, and the mean annual temperature 45° to 50°.

San Juan; mountains in the southern part of the State, which are extremely rugged and include many peaks exceeding 14,000 feet in altitude; source of Rio Grande and San Juan and Uncompahgre rivers and numerous branches of Gunnison River.

San Juan; river of Colorado, New Mexico, and Utah, a large branch of Colorado River, heading in the south slopes of San Juan Mountains and flowing in a westerly course; discharge, near Farmington, N. Mex., June 19 to December 31, 1904, 741,900 acre-feet.

San Juan; town in Hinsdale County.

San Juan; village in Mineral County; altitude, 8,901 feet.

San Juan Forest Reserve; area, 2,246 square miles.

San Luis; creek in Saguache and Costilla counties, tributary to San Luis lakes.

San Luis; hills in Conejos and Costilla counties.

San Luis; lakes without outlet in San Luis Valley, Costilla County, into which San Luis Creek flows; altitude, 7,592 feet.

San Luis; peak on boundary between Saguache and Mineral counties; altitude, 14,100 feet.

San Luis; post village and county seat of Costilla County; population in 1900, 350; altitude, 7,946 feet.

San Luis; valley in the southeastern part of the State, drained southward by the Rio Grande, and by smaller streams which have no outlet; its surface is everywhere very level; altitude, 7,000 to 8,000 feet.

Atlas sheet.

San Miguel; county in the southwestern part of the State; bounded on the north by Montrose and Ouray counties, on the east by Ouray and San Juan counties, on the south by Dolores County, and on the west by Utah. The eastern part consists of high, rugged mountains, part of the San Juan group, and the western part is an arid plateau. Its area is 1,310 square miles, of which 1½ per cent, or 10,388 acres, were under cultivation in 1900. The population in 1900 was 5,379; and of Telluride, the county seat, 2,446. In 1900 the average magnetic declination was 13° 20′ east. The mean annual rainfall is about 20 inches, and the mean annual temperature 45° to 50°.

San Miguel; lake in San Miguel County; altitude, 9,720 feet.

San Miguel; mountains, a name applied to a portion of the San Juan group, in which heads San Miguel River.

San Miguel; peak in San Juan Mountains on boundary between San Miguel and Dolores counties ..... Telluride.

San Miguel; plateau through which San Miguel River cuts a canyon for nearly its entire length.

San Miguel; river in Montrose and San Miguel counties, a right-hand branch of Dolores River, heading in the northwestern San Miguel Mountains and flowing nearly northwest to its mouth in a deep canyon east of Paradox.

San Miguel; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,708 feet.

San Miguel; village in Las Animas County..... Elmoro.

San Pablo; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.

San Pablo; post village in Costilla County.

San Pedro; mesa in Costilla County.

San Pedro; village in Costilla County.

San Rafael; town in Conejos County; population in 1900, 700.

Santa Clara; creek in Las Animas County, a right-hand branch of Cuchara River. Spanish Peaks. Walsenburg.

Santa Clara; station in Huerfano County on Colorado and Southern Railway; altitude, 8,500 feet..... Spanish Peaks.

Santa Clara Junction; station in Huerfano County, on Denver and Rio Grande Railroad.

Santa Fe; mountain in Front Range, Clear Creek County; altitude, 9,000 feet..... Georgetown.

Santa Maria; lake in Mineral County; altitude, 9,415 feet.

Santa Rita; station in Teller County on Colorado Springs and Cripple Creek District Railway.

Sapinero; creek in Gunnison County, a right-hand branch of Gunnison River.

Sapinero; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 7,245 feet.

Sarcillo; canyon in Las Animas County, tributary to Purgatory River. Spanish Peaks.

Sarcillo; station in Las Animas County on Colorado and Wyoming Railway; altitude, 6,689 feet.

Sargent; post village in Saguache County on Denver and Rio *Grande Railroad*; altitude, 8,467 feet.

Atlas sheet.

Saruche; canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.
Sarvis; creek in Routt County, a right-hand branch of Bear Creek.
Satank; village in Garfield County. Railroad name, Bryant.
Saucer; valley in San Miguel County, partly inclosed by a bend of Dolores River.
Saugus; station in Lincoln County on Chicago, Rock Island and Pacific Railway.
Saunders; arroyo in Pueblo County, near Haystack Butte.... Apishapa.
Savage; station in La Plata County on Denver and Rio Grande Railroad.
Savage Basin; valley in San Miguel County ..... Silverton.
Savage Fork; in San Miguel County, a left-hand branch of Marshall Creek, tributary to San Miguel River ..... Telluride.
Sawatch; creek in Saguache County, a right-hand branch of San Luis Creek.
Sawatch; range of high mountains on the west side of the valleys of Eagle and Arkansas rivers, including many peaks which exceed 14,000 feet in altitude, and few passes below timber line.
Saw Mill; creek in Douglas county, a left-hand branch of Plum Creek, tributary to South Platte River ..... Castle Rock.
Sawpit; post town in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,523 feet ..... Telluride.
Sawtooth; range of Elk Mountains on boundary between Pitkin and Gunnison counties ..... Crested Butte.
Sawtooth; summit in Montrose County; altitude, 11,370 feet.
Saxon; mountain in Clear Creek County; altitude, 11,535 feet..... Georgetown.
Scarp; ridge in Gunnison County; altitude, 12,137 feet..... Anthracite.
Schafer; gulch in Hinsdale County, tributary to Henson Creek. Silverton.
Schafer Basin; valley in Hinsdale County..... Silverton.
Schley; post town in Elbert County.
Scholl; post town in Grand County.
Schramm; town in Yuma County on Burlington and Missouri River Railroad; altitude, 4,033 feet.
Schurman; creek in La Plata County, a left-hand branch of La Plata River ..... La Plata.
Schuylkill; mountain in Elk Mountains, Gunnison County; altitude, 12,188 feet..... Anthracite.
Schwanders; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 7,824 feet.
Scofield; village in Gunnison County.
Scotch; creek in Dolores County, a left-hand branch of East Dolores River..... Rico.
Scraggy; butte in Park County; altitude, 8,600 feet.
Scranton; station in Adams County on Colorado Eastern Railroad..... Denver.
Scrub Oak; summit in La Plata County..... La Plata.
Searight; mountain in Grand County; altitude, 11,333 feet.
Searl; gulch in Summit County, tributary to Tenmile Creek ... Leadville.

Atlas sheet.

Seaton; gulch in Clear Creek County, tributary to Clear Creek.. Idaho Springs Special.

Second; creek in Adams County, a right-hand branch of South Platte River..... Denver.

Second; creek in Routt County, a left-hand branch of Williams River.

Sedalia; post village in Douglas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,823 feet..... Castle Rock.

Sedam; station in Jefferson County on Denver, Lakewood and Golden Railroad.

Sedgwick; county in the extreme northeastern part of the State; bounded on the north and east by Nebraska, on the south by Phillips County, and on the west by Logan County. The northwestern part is traversed by South Platte River and by the Union Pacific Railroad. Except for the wide valley through which the South Platte flows, the surface is a rolling plain. The area is 535 square miles, of which nearly 3 per cent, or 9,209 acres, were under cultivation in 1900. The population in 1900 was 971; and of Julesburg, the county seat, 371. In 1900 the average magnetic declination was 13° 10′ east. The mean annual rainfall is about 13 inches, and the mean annual temperature 50° to 55°.

Sedgwick; post village in Sedgwick County on Union Pacific Railroad; altitude, 3,583 feet.

Seebarsee; station in Yuma County on Burlington and Missouri River Railroad.

Seeley; lake in Weld County..... Greeley.

Segundo; post village in Las Animas County on Colorado and Wyoming Railway; altitude 6,597 feet.

Seguro; town in Huerfano County.

Seibert; post village in Kit Carson County on Chicago, Rock Island and Pacific Railway; altitude, 4,705 feet.

Selak; village in Grand County; altitude, 8,650 feet.

Selkirk; station in Park County on Colorado and Southern Railway; altitude, 11,023 feet.

Sellar; post village in Pitkin County on Colorado Midland Railway; altitude, 9,602 feet.

Semper; station in Jefferson County, on the Colorado and Southern and the Burlington and Missouri River railroads; altitude, 5,444 feet..... Denver.

Sentinel; peak in Larimer County.

Sentinel Point; summit in Teller County..... Pikes Peak.

Serape; station in La Plata County on Denver and Rio Grande Railroad.

Servietta; village in Conejos County.

Seven; lakes in El Paso County..... Pikes Peak.

Sevenmile; creek in Chaffee County, a left-hand branch of Arkansas River.

Severance; village in Weld County.

Sewell; station in Pitkin County on Crystal River Railroad; altitude, 6,348 feet.

Shale; station in Mesa County on Denver and Rio Grande Railway; altitude, 4,390 feet.

Atlas sheet.

Sharkstooth; summit in Montezuma County..... La Plata.
Sharpsdale; post village in Huerfano County..... Huerfano.
Shavano; peak in Sawatch Mountains, Chaffee County; altitude, 14,239 feet.
Shavano; village in Chaffee County; altitude, 10,072 feet.
Shaw; gulch in La Plata County, tributary to La Plata River.. La Plata.
Shawnee; post village in Park County on Colorado and Southern Railway.
Shawnee; station in Saguache County on Denver and Rio Grande Railroad.
Shaws; park in Fremont County..... Pikes Peak.
Sheep; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.
Sheep; creek in Larimer County, a left-hand branch of Cache la Poudre River.
Sheep; creek in Larimer County, a right-hand branch of Buckhorn Creek, tributary to Thompson Creek.
Sheep; creek in Park County, a right-hand branch of South Platte River..... Leadville.
Sheep; gulch in Eagle County, tributary to Eagle River..... Tenmile District Special.
Sheep; mountain in Chaffee County; altitude, 12,447 feet.
Sheep; mountain in Dolores County..... Telluride.
Sheep; mountain in Gilpin County..... Blackhawk.
Sheep; mountain in Elk Mountains, Gunnison County; altitude, 13,180 feet..... Lake City.
Sheep; mountain in Huerfano County; altitude, 10,600 feet.. Huerfano Park.
Sheep; mountain in Jefferson County; altitude, 8,675 feet.... Blackhawk.
Sheep; mountain in San Juan County..... Silverton.
Sheep; mountain on boundary between Summit and Eagle counties; altitude, 12,380 feet..... Leadville.
Sheep Draw; creek in Weld County, a small right-hand branch of Cache la Poudre River, tributary to South Platte River..... Greeley.
Sheep Park; valley in Park County..... Leadville.
Sheephorn; town in Eagle County.
Sheffield; station in Denver County on Union Pacffic Railroad.
Shell; canyon in Las Animas County, tributary to Rule Creek. Higbee.
Shenandoah; village in Montrose County.
Shepherd; creek in Montezuma County, a left-hand branch of San Juan River.
Sheridan; mountain in Park Range, Park County; altitude, 14,038 feet..... Leadville.
Sheridan; mountain in San Juan Mountains, La Plata County; altitude, 12,785 feet..... Needle Mountains.
Sheridan; town in Arapahoe County; population in 1900, 442.
Sheridan Junction; station in Jefferson County on Colorado and Southern Railway; altitude, 5,297 feet..... Denver.
Sheridan Lake; county seat of Kiowa County on Missouri Pacific Railway; population in 1900, 100; altitude, 4,065 feet.
Sherman; village in Hinsdale County; altitude, 9,552 feet.... San Cristobal.
Sherman, Mount; in Park Range, Park County; altitude, 14,048 feet..... Leadville.

Atlas sheet.

Sherrod; post village in Gunnison County.
Sherwood; station in Eagle County on Denver and Rio Grande Railroad; altitude, 6,890 feet.
Shields; village in Arapahoe County.
Shimmel; station in Ouray County on Denver and Rio Grande Railroad.
Shingle; peak in Garfield County; altitude, 12,072 feet.
Shirley; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 6,659 feet.
Shirley; village in Saguache County.
Shistos; village in Saguache County.
Shoebeck; gulch in La Plata County, tributary to La Plata River ..... La Plata.
Shoshone; station in Garfield County on Denver and Rio Grande Railroad; altitude, 6,109 feet.
Shuck; creek in Larimer County, a left-hand branch of Big Laramie River.
Sidney; post village in Routt County.
Sidney; station in Elbert County on Colorado and Southern Railway; altitude, 7,032 feet.
Sierra Blanca; group of mountains in Sangre de Cristo Range, Costilla County.
Sierra el Late; isolated summit of volcanic rock rising from a plateau in the southern part of the State.
Signal; butte in Teller County; altitude, 9,300 feet ..... Platte Canyon.
Signal; mountain in Larimer County.
Signal Shot; creek in Routt County, a left-hand branch of Yampa River.
Silex, Mount; summit in San Juan Mountains, San Juan County; altitude, 13,627 feet ..... Needle Mountains.
Silla; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,672 feet.
Sillsville; village in Gunnison County.
Siloam; post town in Pueblo County.
Siloam Spring; station in Garfield County on Denver and Rio Grande Railroad; altitude, 8,176 feet.
Silt; post village in Garfield County on Denver and Rio Grande Railroad; altitude, 5,431 feet.
Silver; creek in Chaffee County, a right-hand branch of Arkansas River.
Silver; creek in Clear Creek County, a left-hand branch of Clear Creek ..... Georgetown.
Silver; creek in Clear Creek County, a right-hand branch of Clear Creek ..... Georgetown. Central City.
Silver; creek in Clear Creek County, a left-hand branch of Fall River, tributary to Clear Creek ..... Central City.
Silver; creek in Dolores County, a left-hand branch of Dolores River. Engineer Mountain. Rico.
Silver; creek in Hinsdale County, a left-hand branch of Cottonwood Creek ..... San Cristobal.
Silver; hill in Gilpin County; altitude, 8,750 feet ..... Blackhawk. Central City Special.
Silver; hill in Park County; altitude, 13,880 feet.

Atlas sheet.

Silver; lake in San Juan County ..... Silverton.
Silver; mountain in La Plata County ..... La Plata.
Silver; mountain in San Miguel County ..... Telluride.
Silver; run in Fremont County, a left-hand branch of Oak Creek, tributary to Arkansas River ..... Canyon City.
Silver Basin; valley in Gunnison County ..... Anthracite.
Silver Basin; valley in Ouray County ..... Silverton.
Silver Cliff; post town in Custer County; population in 1900, 576 ..... Canyon City.
Silverheels, Mount; in Park Range, Park County; altitude, 13,835 feet ..... Leadville.
Silver Lake Basin; valley in La Plata County ..... La Plata.
Silver Lake Basin; valley in San Miguel County ..... Telluride.
Silver Ledge; post village in San Juan County.
Silver Plume; post town in Clear Creek County on Colorado and Southern Railway; population in 1900, 775; altitude, 9,189 feet.
Silverton; county seat of San Juan County on the Denver and Rio Grande, the Silverton Northern, and the Silverton railroads; population in 1900, 1,360; altitude, 9,288 feet... Silverton.
Silverton, Gladstone and Northerly Railroad; line extending from Silverton to Gladstone, a distance of 7 miles.
Silverton Northern Railroad; line extending from Silverton to Eureka, a distance of 9 miles.
Silverton Railroad; a line running from Silverton to Red Mountain, a distance of 14 miles.
Silvia; station in Las Animas County on Denver and Rio Grande Railroad; altitude, 6,042 feet.
Simons; gulch in Montezuma County, tributary to McElmo Creek.
Simons; station in Rio Grande County on Denver and Rio Grande Railroad.
Simpson; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,612 feet.
Sindbad; valley surrounded by cliffs, at the base of Sierra la Sal.
Sixmile; canyon in Boulder County, tributary to Lefthand Creek ..... Boulder.
Sixmile; creek in Fremont County, a left-hand branch of Arkansas River ..... Canyon City.
Sixmile; creek in Larimer County, a left-hand branch of Cache la Poudre River.
Sixmile; creek in Pueblo County, a right-hand branch of Arkansas River ..... Nepesta.
Sixmile Park; valley in Fremont County ..... Pikes Peak.
Skinners; station in El Paso County on Atchison, Topeka and Santa Fe Railway; altitude, 5,772 feet.
Skull; creek in Routt County, a left-hand branch of Bear River.
Skull Creek; pass in Routt County; altitude, 7,797 feet.
Skunk; creek in Gunnison County, a right-hand branch of Lake Fork Gunnison River ..... Lake City.
Slaghts; station in Park County on Colorado and Southern Railway; altitude, 8,028 feet.

Atlas sheet.

Slagle Basin; valley in San Juan County ..... Silverton.
Slate; peak in Elk Mountains, Gunnison County; altitude, 12,989 feet ..... Anthracite.
Slate; river in Gunnison County, a right-hand branch of East River, tributary to Gunnison River ..... Crested Butte. Anthracite.
Slater; post town in Routt County.
Slaters Fork; in Routt County, a left-hand branch of Little Snake River, tributary to Yampa River.
Slaughterhouse; gulch in Hinsdale County, tributary to Lake Fork Gunnison River ..... Lake City.
Slide Rock; mountain in La Plata County ..... Durango.
Sliderock Basin; valley in Montezuma County ..... La Plata.
Sligo; station in Weld County on Burlington and Missouri River Railroad.
Sloan; lake in Denver County ..... Denver.
Sloan; lake in Hinsdale County ..... Silverton.
Sloan; station in La Plata County on Denver and Rio Grande Railroad.
Sloane; station in Eagle County on Colorado Midland Railway; altitude, 7,167 feet.
Slumgullion; creek in Gunnison County, a left-hand branch of East River, tributary to Gunnison River ..... Crested Butte.
Slumgullion; gulch in Hinsdale County, tributary to San Cristobal Lake ..... San Cristobal.
Smith; canyon in Otero and Las Animas counties, tributary to Purgatory River ..... Higbee.
Smith; gulch in Fremont County, tributary to Currant Creek. Pikes Peak.
Smith; hill in Gilpin County on Colorado and Southern Railway; altitude, 7,620 feet ..... Blackhawk.
Smith; hollow in Las Animas County, a right-hand branch of Apishapa River ..... Apishapa.
Smith; lake in Denver County ..... Denver.
Smith Hill; gulch in Gilpin County, tributary to North Clear Creek ..... Blackhawk.
Smiths Fork; in Montrose and Delta counties, a right-hand branch of Gunnison River.
Smithy; mountain in Boulder County; altitude, 7,100 feet .... Boulder.
Smoky; creek in Cheyenne County, a left-hand branch of Smoky Hill River ..... Cheyenne Wells.
Smoky Hill; river originating in North Fork, Kit Carson County, a large branch of Kansas River.
Smuggler; mountain in San Juan Mountains, Pitkin County.
Smuggler; post town in San Miguel County.
Smuggler Mountain; creek in Pitkin County, a right-hand branch of Roaring Fork.
Snake; river in Summit County, a right-hand branch of Blue River, tributary to Grand River.
Snare; creek in Hinsdale County, a right-hand branch of Cottonwood Creek, tributary to Lake Fork Gunnison River .. Silverton.
Sneffels; mountain in San Juan Mountains, Ouray County; altitude, 14,158 feet.
Sneffels; post village in Ouray County ..... Silverton.
Snipes; post village in Mesa County.

Atlas sheet.

Snow; station in Dolores County on Denver and Rio Grande Railroad.

Snowden; lake in Otero County ..... Apishapa.

Snowden; peak in San Juan Mountains, San Juan County; altitude, 13,070 feet..... Needle Mountains.

Snowden; station in Lake County on Colorado Midland Railway; altitude, 9,388 feet.

Snowdrift; gulch in Clear Creek County, tributary to Clear Creek.

Snowmass; creek in Pitkin County, a left-hand branch of Roaring Fork, tributary to Grand River ..... Aspen.

Snowmass; mountain in Elk Mountains, Gunnison County; altitude, 13,970 feet.

Snowmass; post village in Pitkin County on Colorado Midland Railway; altitude, 6,880 feet.

Snowslide; gulch in La Plata County, tributary to La Plata River ..... La Plata.

Snowstorm; peak in La Plata County..... La Plata.

Snyder; post village in Morgan County on Union Pacific Railroad; altitude, 4,172 feet.

Sockrider; peak in San Juan Mountains, Dolores County; altitude, 12,315 feet..... Rico.

Soda; creek in Clear Creek County, a right-hand branch of Clear Creek..... Georgetown.

Soda; creek in Grand County, a right-hand branch of Grand River.

Soda; creek in Pueblo County, a left-hand branch of Rock Creek, tributary to Arkansas River..... Pueblo.

Soda; creek in Routt County, a right-hand branch of Bear Creek.

Soda; gulch in San Juan County, tributary to Cement Creek.. Silverton.

Soda; Springs in Lake County..... Leadville.

Solar; station in Huerfano County on Denver and Rio Grande Railroad.

Soldiers Home; station in Rio Grande County on Denver and Rio Grande Railroad.

Soledad; station in La Plata County on Denver and Rio Grande Railroad.

Somerset; post village in Gunnison County on Denver and Rio Grande Railroad; altitude, 6,055 feet.

Sommers; station in El Paso County on Atchison, Topeka and Santa Fe Railway.

Sonora; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,878 feet. Post-office, Lime.

Sopris; creek in Pitkin County, a left-hand branch of Roaring Fork.

Sopris; peak in Elk Mountains, Pitkin County; altitude, 12,823 feet.

Sopris; post village in Las Animas County on Colorado and Southern Railway..... Spanish Peaks.

Sopris; town in Garfield County on Colorado Midland Railway; altitude, 6,051 feet.

Atlas sheet.

Sopris Junction; station in Las Animas County, on the Colorado and Southern and the Colorado and Wyoming railways.

Sorrento; station in Cheyenne County on Union Pacific Railroad; altitude, 4,382 feet.

Sour; creek in Grand County, a left-hand branch of North Platte River.

South; canyon in Las Animas County, tributary to Apishapa River..... Apishapa.

South; peak on boundary between Park and Lake counties... Leadville.

South Arkansas; river, a right-hand branch of Arkansas River. It heads in Sawatch Range, and flows in an easterly course to its junction with the Arkansas, a few miles below Salida.

South Boulder; creek in Boulder County, a right-hand branch of Boulder Creek, tributary to South Platte River..... Denver.

South Boulder; peak in Boulder County; altitude, 8,533 feet. Denver.

South Cañon; post village in Garfield County on Colorado Midland Railway; altitude, 5,683 feet.

South Cañon; town in Fremont County; population in 1900, 958.

South Cherry; creek in Arapahoe County, a right-hand branch of Cherry Creek, tributary to South Platte River ..... Denver.

South Cheyenne; creek in El Paso County, fork of Cheyenne Creek, tributary to Fountain Creek..... Colorado Springs.

South Cheyenne; station in El Paso County on Colorado Springs and Cripple Creek District Railway.

South Clear; creek in Clear Creek County, a right-hand branch of Clear Creek..... Georgetown.

South Creede; station in Mineral County on Denver and Rio Grande Railroad; altitude, 8,772 feet.

South Denver; post village in Denver County, on the Atchison, Topeka and Santa Fe and the Colorado and Southern railways; altitude, 5,253 feet.

Southern Junction; station in La Plata County on Denver and Rio Grande Railroad.

Southern Ute; town in La Plata County.

South Fork; post village in Rio Grande County on Denver and Rio Grande Railroad; altitude, 8,188 feet.

South Fork; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,176 feet.

South Lookout; peak in San Juan County..... Telluride.

South Mam; summit on Battlement Mesa on boundary between Garfield and Mesa counties; altitude, 10,973 feet.

South Oak; creek in Huerfano County, a right-hand branch of Huerfano River..... Huerfano Park.

South Park; high mountain valley near the central part of the State, drained southward by South Platte River; the surface is generally level and ranges from 8,000 to 10,000 feet.

South Park Junction; station in Arapahoe County, on the Atchison, Topeka and Santa Fe and the Colorado and Southern railways.

South Platte; river, one of the two forks of Platte River; *heading in mountains* of South Park in North and South

Atlas sheet.

South Platte—Continued.
forks; traverses that high mountain valley in a southeasterly direction, and turning to the northeast winds its way through the broken ridges of Front Range to the plains; thence flowing north and northeast and finally nearly east, it joins the North Platte near the city of North Platte, Nebr.; discharge at Denver for 1904, 151,700 acre-feet.
South Platte; post village in Jefferson County on Colorado and Southern Railway; altitude, 6,097 feet.
South Platte; village in Logan County.
South Pueblo; village in Pueblo County.
South Rattlesnake; butte in Las Animas and Huerfano counties; altitude, 6,442 feet ..... Apishapa.
South River; peak in San Juan Mountains, Mineral County; altitude, 13,160 feet.
South Rush; creek, right-hand branch of Rush Creek, tributary to Arkansas River.
South St. Vrain; creek in Boulder County, a right-hand branch of St. Vrain Creek, tributary to South Platte River. Boulder.
South Sopris; creek in Pitkin County, a left-hand branch of Roaring Fork.
South Table; mountain in Jefferson County; altitude, 6,167 feet ..... Denver.
South Veta; creek in Huerfano County, a left-hand branch of Cuchara River, tributary to Huerfano River ..... Huerfano Park.
South Willis; gulch in Gilpin County, tributary to North Clear Creek ..... Central City Special.
Spanish; creek in Saguache County, a left-hand branch of Cottonwood Creek, tributary to San Luis Creek.
Spanish; peaks, two in number, on boundary between Las Animas and Huerfano counties; altitude, 13,620 and 12,708 feet.
Spar; village in Mineral County.
Sparkill; village in Pitkin County.
Sparling; gulch in Hinsdale County, tributary to Lake Fork Gunnison River ..... Lake City.
Specimen; mountain in Larimer County.
Spence; creek in Archuleta County, a right-hand branch of San Juan River.
Spencer; gulch in La Plata County, a left-hand branch of La Plata River ..... La Plata.
Spencer; post town in Gunnison County; population in 1900, 52.
Spencer Basin; valley in San Juan County ..... Silverton.
Spicer; post village in Larimer County.
Spikebuck; station in Fremont County on Denver and Rio Grande Railroad; altitude, 5,896 feet.
Spiller; peak in La Plata Mountains, on boundary between Montezuma and La Plata counties ..... La Plata.
Spinney; station in Park County on Colorado Midland Railway; altitude, 8,637 feet.
Spirit; gulch in Ouray County, tributary to Red Mountain Creek ..... Silverton.

	Atlas sheet.
Sprague; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.	
Spring; canyon in Baca County, tributary to Cimarron River.	Vilas.
Spring; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.	
Spring; creek in Gunnison County, a left-hand branch of Taylor River, tributary to Gunnison River	Crested Butte.
Spring; creek in Kit Carson and Arapahoe counties, a right-hand branch of South Fork Republican River.	
Spring; creek in La Plata County, a left-hand branch of Animas River	Durango.
Spring; creek in Montrose County, a left-hand branch of Uncompahgre River.	
Spring; creek in Rio Grande County, a right-hand branch of Rio Grande.	
Spring; creek in San Miguel County, a left-hand branch of Dolores River.	
Spring; creek in Teller County, a left-hand branch of Oil Creek, tributary to Arkansas River	Pikes Peak.
Spring; creek in Weld County, a left-hand branch of Pawnee Creek, tributary to South Platte River.	
Spring; gulch in Boulder County, tributary to Fourmile Creek	Boulder.
Spring; gulch in Boulder County, tributary to Lefthand Creek	Boulder.
Spring; gulch in Clear Creek County, tributary to Clear Creek.	Georgetown.
Spring; gulch in Gilpin County	Central City Special.
Spring; gulch in Gunnison County, tributary to Lake Fork Gunnison River	Lake City.
Spring; gulch in La Plata County, tributary to Cherry Creek.	La Plata.
Spring; hill in Logan County.	
Spring Branch; in Pueblo County, a right-hand branch of St. Charles River	Pueblo.
Springdale; post village in Boulder County; altitude, 8,580 feet	Boulder.
Springer; station in Park County on Colorado Midland Railway; altitude, 8,260 feet.	
Springfield; post town and county seat of Baca County; population in 1900, 44	Springfield.
Spring Gulch; town in Pitkin County on Colorado Midland Railway; altitude, 5,286 feet.	
Spruce; creek in Summit County, a left-hand branch of Blue River, tributary to Grand River	Leadville.
Spruce; gulch in Boulder County, tributary to Lefthand Creek.	Boulder.
Spruce; gulch in Dolores County, tributary to East Dolores River	Rico.
Spruce Creek; station in Garfield County on Denver and Rio Grande Railroad.	
Squaw; creek in Chaffee County, a right-hand branch of Arkansas River.	
Squaw; gulch in Teller County, tributary to Cripple Creek...	Cripple Creek Special.
***Squaw**; mountain* in Teller County, near Cripple Creek; *altitude, 10,376 feet*	

Atlas sheet.

Squaw; mountain in Front Range; altitude, 13,093 feet.
Squirrel; gulch in Clear Creek County, tributary to Soda Creek ..... Georgetown.
Stag; mesa in La Plata County ..... Needle Mountains.
Stage; canyon in Las Animas County, tributary to Purgatory River ..... Timpas.
Stamford; town in Las Animas County; altitude, 9,500 feet.
Stampede; creek in Grand County, a right-hand branch of Grand River.
Stanley; village in Costilla County.
Stapleton; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,140 feet.
Star; peak in Sawtooth Range on boundary between Pitkin and Gunnison counties; altitude, 13,562 feet..... Crested Butte.
Starkville; post village in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 6,337 feet..... Spanish Peaks.
Starvation; creek in La Plata County, a left-hand branch of Cherry Creek, tributary to La Plata River ..... La Plata.
State Reservoir; artificial lake in Las Animas County..... Spanish Peaks.
Steamboat; mountain in Boulder County; altitude, 6,186 feet. Boulder.
Steamboat; springs in Larimer County.
Steamboat Springs; post village in Routt County; altitude, 6,781 feet.
Steele; hollow in Pueblo County, tributary to Fountain Creek. Pueblo.
Steels Fork; in El Paso and Lincoln counties, a right-hand branch of Horse Creek, tributary to Arkansas River. Big Springs. Sanborn.
Stephen; creek in Delta County, a right-hand branch of North Fork Gunnison River.
Sterling; post town and county seat of Logan County, on the Union Pacific and the Burlington and the Missouri River railroads; population in 1900, 998; altitude, 3,932 feet.
Stevens; creek in La Plata County, a left-hand branch of Animas River..... Durango.
Stewart; peak in Saguache County; altitude, 14,032 feet.
Stillwater; creek in Grand County, a right-hand branch of Grand River.
Stinking; arroyo in Pueblo County, a left-hand branch of St. Charles River ..... Pueblo.
Stinking; spring in Pueblo County..... Pueblo.
Stock; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.
Stoiber; station in San Juan County, on Denver and Rio Grande Railroad.
Stoll; mountain in Park County; altitude, 10,915 feet..... Pikes Peak.
Stone; canyon in Boulder County, tributary to St. Vrain Creek. Boulder.
Stoneham; station in Weld County on Burlington and Missouri River Railroad; altitude, 4,583 feet.
Stone Prairie; creek in Larimer County, a left-hand branch of Buckhorn Creek, tributary through Thompson Creek to South Platte River.
Stoner; creek in Dolores County, a left-hand branch of West Dolores River, tributary to Dolores River ..... Rico.

	Atlas sheet.
Stoner Creek; station in Montezuma County on Denver and Rio Grande Railroad; altitude, 7,480 feet.	
Stonewall; post village in Las Animas County.	
Stonewall; valley between North and South forks of Purgatory River.	
Stonington; post village in Baca County	Vilas.
Stony; gulch in Rio Blanco County, tributary to Piceance Creek.	
Stony; gulch in San Juan County, tributary to Cunningham Creek	Silverton.
Stony; mountain in San Juan Mountains, San Miguel County; altitude, 12,677 feet	Telluride.
Stony; pass in San Juan County; altitude, 12,592 feet	Silverton.
Stony Creek; town in Montezuma County.	
Stony Cut; in Hinsdale County, tributary to Lake Fork Gunnison River	Lake City.
Storm; peak in Dolores County	Rico.
Storm; peak in San Juan County	Silverton.
Storm; ridge in Gunnison County; altitude, 11,859 feet	Anthracite.
Storm King; peak in San Juan Mountains, San Juan County; altitude, 13,742 feet	Needle Mountains.
Stormy; peak in Douglas County; altitude, 9,200 feet	Platte Canyon.
Stormy; peak in Park County; altitude, 11,748 feet	Platte Canyon.
Stout; creek in Fremont County, a left-hand branch of Big Cottonwood Creek, tributary to Arkansas River.	
Stout; post village in Larimer County on Colorado and Southern Railway; altitude, 5,479 feet.	
Strassburg; station in Arapahoe County on Union Pacific Railroad; altitude, 5,576 feet.	
Stratter; station in Delta County on Denver and Rio Grande Railroad; altitude, 4,870 feet.	
Stratton; creek in Larimer County, a right-hand branch of South Fork Cache la Poudre River.	
Stratton; station in Teller County on Florence and Cripple Creek Railroad; altitude, 9,808 feet.	
Stratton Junction; station in El Paso County, on the Colorado Springs and Cripple Creek District and the Florence and Cripple Creek railroads.	
Straub; mountain in Fremont County	Cripple Creek Special.
Straub; mountain in Teller County	Pikes Peak.
Strawberry; creek in Rio Blanco County, a right-hand branch of White River.	
Stray Horse; gulch in Lake County, tributary to Arkansas River	Leadville.
Strong; post village in Huerfano County.	
Stronita; spring in Jefferson County on Colorado and Southern Railway.	
Struby; station in Douglas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,485 feet.	
Stuart; creek in Rio Blanco County, a left-hand branch of Piceance Creek.	

Atlas sheet.

Stuart; station in Kiowa County on Missouri Pacific Railway; altitude, 4,023 feet.

Sublette; station near south line of Conejos County on Denver and Rio Grande Railroad; altitude, 9,276 feet.

Sublime; post village in El Paso County on Colorado Springs and Cripple Creek District Railway; altitude, 7,158 feet. Railroad name, Point Sublime.

Suffield; village in Las Animas County; altitude, 6,211 feet.

Suffolk; town in San Miguel County.

Sugar City; post town in Otero County on Missouri Pacific Railway; population in 1900, 689.

Sugarloaf; creek in Summit County, a left-hand branch of Tenmile Creek, tributary to Snake River ..... Leadville.

Sugarloaf; gulch in Summit County, tributary to West Fork Tenmile Creek. Tenmile District Special.

Sugarloaf; mountain in Boulder County; altitude, 8,920 feet.. Boulder.

Sugarloaf; peak in Front Range, Clear Creek County; altitude, 12,513 feet ..... Georgetown.

Sugarloaf; post village in Boulder County on Colorado and Southern Railway; altitude, 6,824 feet ..... Boulder.

Sugarloaf; summit on boundary between Eagle and Summit counties; altitude, 12,556 feet ..... Leadville.

Sugarloaf; summit in Park County.

Sugarloaf Rock; summit in Hinsdale County; altitude, 10,831 feet ..... Lake City.

Sull; creek in Huerfano County, a left-hand branch of Cuchara River, tributary to Huerfano River.

Sullivan; station in Arapahoe County on Colorado and Southern Railway; altitude, 5,477 feet. Post-office, Oakes.

Sulphur; creek in Dolores County, a left-hand branch of West Dolores River, tributary to Dolores River ..... Rico.

Sulphur; creek in Dolores County, a right-hand branch of East Dolores River ..... Rico.

Sulphur; creek in Rio Blanco County, a right-hand branch of Fourmile Creek, tributary to White River.

Sulphur; gulch in Douglas County, tributary to Cherry Creek. Denver.

Sulphur; post town in Rio Blanco County.

Sulphur; spring in Park County.

Sulphur; spring in Routt County.

Sulphur Springs; post village and county seat of Grand County; population in 1900, 106.

Sultan; creek in San Juan County, a right-hand branch of Animas River ..... Silverton.

Sultan; mountain in San Juan Mountains, San Juan County; altitude, 13,336 feet ..... Silverton.

Sultana; town in San Miguel County.

Summerville; village in Boulder County; altitude, 7,200 feet. Boulder.

Summit; county near the center of the State, bounded on the north by Grand County, on the east by Grand, Clear Creek, and Park counties, on the south by Park and Lake counties, and on the west by Eagle County; it includes the upper valley of Blue River, extending from Williams River Mountains on the east to Park Range on the west. Its area is

Atlas sheet.

Summit—Continued.
603 square miles, of which 1 per cent, or 4,031 acres, were under cultivation in 1900. The population in 1900 was 2,744; and of Breckenridge, the county seat, 976. In 1900 the average magnetic declination was 14° 00′ east. The mean annual rainfall is about 27 inches, and the mean annual temperature 40° to 45°.

Summit; creek in San Miguel County, a right-hand branch of San Miguel River ..... Telluride.

Summit; lake in Clear Creek County; altitude, 12,740 feet.... Georgetown.

Summit; peak in San Juan Mountains on boundary between Archuleta and Conejos counties; altitude, 13,323 feet.

Summit; peak in Park County; altitude, 10,120 feet.

Summit; station in El Paso County on Manitou and Pikes Peak Railway.

Summit; station in San Juan County on Silverton Railroad.. Silverton.

Summit; station in Teller County on Colorado Midland Railway ..... Pikes Peak.

Summitville; post village in Rio Grande County; altitude, 11,089 feet.

Sumner; village in Conejos County.

Sun; creek in Gunnison County, a right-hand branch of North Beaver Creek, tributary to Gunnison River.

Sunetha; station in Archuleta County on Denver and Rio Grande Railroad.

Sunflower; station in Conejos County on Denver and Rio Grande Railroad.

Sunlight; peak in San Juan Mountains, La Plata County; altitude, 14,053 feet..... Needle Mountains.

Sunlight; post village in Garfield County on Colorado Midland Railway; altitude, 7,572 feet.

Sunny; peak in Routt County; altitude, 7,442 feet.

Sunnyside; creek in Routt County, a right-hand branch of Grand River.

Sunnyside; village in Boulder County.

Sunset; post village in Boulder County on Colorado and Northwestern Railroad..... Boulder.

Sunshine; mountain in San Juan Mountains, San Miguel County; altitude, 12,945 feet..... Telluride.

Sunshine; peak in Hinsdale County; altitude, 14,018 feet.... San Cristobal.

Sunshine; post village in Boulder County; altitude, 7,151 feet. Boulder.

Sunshine; station in Garfield County on Colorado Midland Railway; altitude, 7,815 feet.

Sunshine; town in Huerfano County on Denver and Rio Grande Railroad.

Sunshine Spur; station on Colorado Midland Railway; altitude, 7,553 feet.

Superior; post village in Boulder County on Colorado and Southern Railway.

Surber; post village in El Paso County.

Surface; creek in Delta County, a right-hand branch of Gunnison River.

Suttle; *village in* Delta County.

Atlas sheet.

Swallows; post village in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,875 feet.
Swan; village in Summit County.
Swan Basin; valley in Gunnison County ..... Anthracite.
Swandyke; post village in Summit County.
Swansea; gulch in San Juan County, tributary to Animas River ..... Silverton.
Swansons; station in Summit County on Denver and Rio Grande Railroad.
Swamp; canyon in San Miguel County, tributary to Lake Fork San Miguel River ..... Telluride.
Swampy; pass in Gunnison County ..... Anthracite.
Swede; lakes in Boulder County ..... Niwot.
Sweetwater; creek in Garfield and Eagle counties, a right-hand branch of Grand River.
Swift; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.
Swink; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,116 feet. Post-office, Fairmount.
Swissvale; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,856 feet.
Sylvanite; station in Teller County on Midland Terminal Railway.
Symons; station in Otero County on Atchison, Topeka and Santa Fe Railway; altitude, 4,684 feet.
T; gulch in Hinsdale County, tributary to Henson Creek ..... Lake City.
Tabequatche; creek in Montrose County, a right-hand branch of San Miguel River.
Tabernash; post village in Grand County.
Table; mesa in Boulder County ..... Niwot.
Table; mountain in Boulder County; altitude, 5,385 feet ..... Niwot.
Table; mountain in Larimer County.
Table Rock; village in Douglas County ..... Castle Rock.
Tack; mountain in Summit County.
Taclamur; post village in Fremont County.
Talamantes; creek in Routt County, a right-hand branch of Vermilion Creek, tributary to Green River.
Talian; station in Archuleta County on Denver and Rio Grande Railroad.
Tallahassee; creek in Fremont County, a left-hand branch of Arkansas River. Pikes Peak. Canyon City.
Talpa; post village in Huerfano County.
Tampa; station in Weld County on Burlington and Missouri River Railroad.
Tank; creek in La Plata County, a left-hand branch of Animas River. Needle Mountains. Engineer Mountain.
Tank; peak in Routt County; altitude, 8,929 feet.
Tarryall; creek in Park County, a left-hand branch of South Platte River ..... Platte Canyon.
Tarryall; mountains of Front Range separating Tarryall Creek from other branches of South Platte River ..... Platte Canyon.
Tarryall; pass in Park County; altitude, 12,466 feet.

Atlas sheet.

Tarryall; peak in Tarryall Range, in Park County; altitude, 11,300 feet ..... Platte Canyon.

Tarryall; post village in Park County; altitude, 10,254 feet.

Taylor; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.

Taylor; creek in Montezuma County, a right-hand branch of Dolores River ..... La Plata.

Taylor; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.

Taylor; mountain in Boulder County; altitude, 9,134 feet .... Boulder.

Taylor; pass in Gunnison County ..... Crested Butte.

Taylor; peak in Sawtooth Range on boundary between Gunnison and Pitkin counties; attitude, 13,419 feet ..... Crested Butte.

Taylor; river in Gunnison County, a right-hand branch of Gunnison River ..... Crested Butte.

Taylor; station in Pueblo County, on Atchison, Topeka and Santa Fe Railway; altitude, 4,854 feet.

Taylor Creek; station in Eagle County on Colorado Midland Railway.

Taylor Park; valley in Gunnison County.

Taylor River; station in Gunnison County on Denver and Rio Grande Railroad.

Teachout; station in Gunnison County on Colorado and Southern Railway; altitude, 8,027 feet.

Tecalote; creek in Las Animas County, a left-hand branch of West Carrizo Creek, tributary to Cimarron River ..... Mount Carrizo.

Telescope; mountain in Dolores County; altitude, 12,231 feet. Rico.

Teller; county near the center of the State; bounded on the north by Douglas County, on the east by El Paso County, on the south by Fremont County, and on the west by Park County. Its surface includes high, mountainous territory at the heads of Fountain Creek and other branches of Arkansas River. Its area is 551 square miles, of which nearly 2 per cent, or 4,685 acres, were under cultivation in 1900. The population in 1900 was 29,002; and of Cripple Creek, the county seat, 10,147. The mean annual rainfall is about 14 inches, and the mean annual temperature 40° to 45°.

Teller; lake in Boulder County ..... Niwot.

Teller; post village in Mineral County.

Teller; village in Larimer County.

Telluride; county seat of San Miguel County on Denver and Rio Grande Railroad; population in 1900, 2,446; altitude, 6,744 feet ..... Telluride.

Telluride; peak in San Juan Mountains, San Miguel County.. Telluride.

Tenderfoot; creek in Montezuma County, a right-hand branch of East Dolores River ..... Rico.

Tenderfoot; hill in Teller County ..... Cripple Creek Special.

Tenmile; creek in San Juan County, a left-hand branch of Animas River ..... Needle Mountains.

Tenmile; creek in Summit County, tributary to Blue River; discharge near Kokomo, March 6 to November 20, 1904, *70,870 acre-feet* ..... Leadville.

Atlas sheet.

Tenmile; peak in Park Range, Summit County; altitude, 12,800 feet.

Tenmile; station in Summit County on Denver and Rio Grande Railroad.

Tennessee; pass at head of Eagle and Arkansas rivers; altitude, 10,229 feet.

Tennessee Colony; village in Weld County.

Tennessee Fork; in Lake County, a right-hand branch of Arkansas River ..... Leadville.

Tennessee Pass; station at summit of pass of same name, between Eagle and Lake counties, on Denver and Rio Grande Railroad ..... Leadville.

Teocalli; mountain in Gunnison County; altitude, 13,220 feet..... Crested Butte.

Tercio; post village in Las Animas County on Colorado and Wyoming Railway; altitude, 7,819 feet.

Terrace; village in Conejos County.

Terrible; creek in Routt County, a left-hand branch of Bear River, tributary to Yampa River.

Terry; lake in Boulder County ..... Niwot.

Texas; creek in Fremont and Custer counties, a right-hand branch of Arkansas River.

Texas; creek in Gunnison County, a right-hand branch of Taylor River.

Texas Creek; post village in Fremont County on Denver and Rio Grande Railroad; altitude, 6,198 feet.

Texas Mill; village in Fremont County ..... Cripple Creek Special.

Thatcher; post village in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,408 feet..... Apishapa.

The Hook; station in La Plata County on Denver and Rio Grande Railroad; altitude, 8,138 feet.

Third; creek in Adams County, a right-hand branch of South Platte River ..... Denver.

Thirteenmile; creek in Rio Blanco County, a right-hand branch of Piceance Creek, tributary to White River.

Thirty-ninemile; mountain in Park County; altitude, 11,000 feet.

Thirty-onemile; creek in Park County, a right-hand branch of Currant Creek, tributary to Arkansas River.

Thomasville; post village in Pitkin County on Colorado Midland Railway; altitude, 7,968 feet.

Thompson; creek in Weld County, a left-hand branch of South Platte River..... Greeley.

Thompson; gulch in Lake County, tributary to Arkansas River. Leadville.

Thompson Park; valley in La Plata County; altitude, 7,370 feet.

Thornburg; post village in Rio Blanco County.

Thornton; station in Mineral County on Denver and Rio Grande Railroad.

Three; buttes in Phillips County.

Threemile; creek in Park County, a right-hand branch of South Platte River.

Three Needles; summits in San Miguel County ..... Telluride.

	Atlas sheet.
Thunder; butte in Douglas County; altitude, 9,779 feet	Platte Canyon.
Thunder; mountain in La Plata County	Needle Mountains.
Thurman; post village in Washington County.	
Tiger; gulch in San Juan County, tributary to Cement Creek.	Silverton.
Tijeras; village in Las Animas County	Spanish Peaks.
Tile; station in Fremont County on Denver and Rio Grande Railroad.	
Tilton; mountain in Elk Mountains, Gunnison County; altitude, 12,633 feet	Crested Butte.
Timber; canyon in Las Animas County, tributary to Purgatory River	Spanish Peaks.
Timnath; post village in Larimer County; altitude, 4,878 feet.	
Timpas; creek in Otero County, a right-hand branch of Arkansas River.	Catlin. Timpas.
Timpas; post village in Otero County; altitude, 4,417 feet.	
Tin Cup; post village in Gunnison County; population in 1900, 64.	
Tinley; canyon in Las Animas County, tributary to Purgatory River	Spanish Peaks.
Tioga; village in Huerfano County	Walsenburg.
Tip Top; station in Elbert County on Chicago, Rock Island and Pacific Railway; altitude, 6,887 feet.	
Tirbircio; creek in La Plata County, a left-hand branch of La Plata River	La Plata.
Tob; arroyo in Las Animas County, a right-hand branch of Chaquaqua Creek, tributary to Purgatory River	Mesa de Maya.
Tobasco; post village in Las Animas County on Colorado and Southern Railway.	
Tobe; canyon in Las Animas County, tributary to Purgatory River	Mesa de Maya.
Todd; gulch in Boulder County, tributary to Fourmile Creek.	Boulder.
Todd Point; end of plateau in Otero County; altitude, 4,627 feet	Catlin.
Tolland; post village in Gilpin County, on Denver, Northwestern and Pacific Railway.	
Toltec; station near south line of Conejos County on Denver and Rio Grande Railroad; altitude, 9,965 feet.	
Toltec Gorge; station in Conejos County on Denver and Rio Grande Railroad.	
Toll Gate; creek in Arapahoe County, a left-hand branch of South Platte River	Denver.
Toluca; station in Douglas County on Denver and Rio Grande Railroad; altitude, 5,663 feet.	
Tomah; station in Douglas County, on Atchison, Topeka and Santa Fe Railroad; altitude, 6,436 feet.	
Tomichi; creek in Gunnison County, a left-hand branch of Gunnison River.	
Tomichi; post village in Gunnison County.	
Tomichi Dome; summit in Gunnison County; altitude, 11,384 feet.	
Tongue; creek in Delta County, a right-hand branch of Gunnison River.	

Atlas sheet.

Tongue; mesa-like spur of San Juan Mountains extending northward between Uncompahgre River and Cebolla Creek.

Topaz; mountain in Tarryall Mountains, Park County; altitude, 9,200 feet.

Topeka; gulch in San Juan County, tributary to Cement Creek. Silverton.

Toponas; creek in Routt County, a left-hand branch of Egeria Creek, tributary to Grand River.

Toponas; post village in Routt County.

Torres; post village in Las Animas County.

Torrey; peak in Front Range, Summit County; altitude, 14,336 feet.

Torrington; village in Teller County.

Tourtelotte; village in Pitkin County.

Tower; mountain in San Juan Mountains, San Juan County; altitude, 13,444 feet..... Silverton.

Tower Junction; station in Boulder County on Burlington and Missouri River Railroad; altitude, 5,292 feet.

Towner; post village in Kiowa County on Missouri Pacific Railway; altitude, 3,924 feet ..... Granada.

Townsend; village in Arapahoe County.

Townsite; town in Baca County.

Trachyte; mountain in Teller County; altitude, 10,876 feet... Pikes Peak.

Tracy; station in El Paso County on Midland Terminal Railway.

Trail; creek in Clear Creek County, a right-hand branch of Clear Creek. Central City. Georgetown.

Trail; creek in Grand County, a right-hand branch of Grand River.

Trail; creek in Larimer County, a left-hand branch of Cache la Poudre River.

Trappers; lake in Gilpin County.

Travis; station in Saguache County on Denver and Rio Grande Railroad; altitude, 7,579 feet.

Treasure; mountain in San Juan County..... Silverton.

Treasury; mountain in Elk mountains, Gunnison County; altitude, 13,200 feet.

Treatdale; station in Jefferson County on Denver, Lakewood and Golden Railroad.

Trident; mesa in Gunnison County, running northward from San Juan Mountains; it is divided into three parts by branches of the Gunnison.

Trilby; station in Larimer County on Colorado and Southern Railway; altitude, 5,015 feet.

Trimble; pass in San Juan Mountains, La Plata County..... Needle Mountains.

Trimble; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,563 feet..... Durango.

Trimmed Tree; summit in Las Animas County ..... Spanish Peaks.

Trinchera; creek in Las Animas County, a right-hand branch of Purgatory River. Elmoro. Mesa de Maya.

Trinchera; mountain in Sangre de Cristo Range, on boundary between Las Animas, Costilla, and Huerfano counties; altitude, 13,546 feet.

	Atlas sheet.
Trinchera; post village in Las Animas County on Colorado and Southern Railway; altitude, 5,741 feet. Railroad name, Mortimer	Elmoro.
Trinchera; river in Costilla County, a left-hand branch of Rio Grande.	
Trinchera; station in Costilla County on Denver and Rio Grande Railroad; altitude, 8,104 feet.	
Trinidad; county seat of Las Animas County on the Atchison, Topeka and Santa Fe, the Colorado and Southern, and the Denver and Rio Grande railroads; population in 1900, 5,345; altitude, 5,985 feet.	
Trinidad Junction; station on Denver and Rio Grande Railroad; altitude, 4,657 feet.	
Trinity; peaks in San Juan Mountains, San Juan County; altitudes, 13,752, 13,804, and 13,745 feet	Needle Mountains.
Troublesome; creek in Grand County, a right-hand branch of Grand River.	
Troublesome; peak in Grand County; altitude, 11,500 feet.	
Troublesome; post village in Grand County.	
Trout; creek in Chaffee County, a left-hand branch of Arkansas River.	
Trout; creek in Douglas County, a right-hand branch of South Platte River	Platte Canyon.
Trout; creek in Gunnison County, a right-hand branch of Lake Fork Gunnison River	Lake City.
Trout; creek in Park County, a left-hand branch of South Platte River.	
Trout; lake in San Miguel County; altitude, 9,800 feet.	
Trout Creek; pass through Trout Creek Hills, between Chaffee and Park counties; altitude, 9,346 feet.	
Trout Creek Pass; hills in Park Range.	
Trout Lake; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 9,790 feet	Telluride.
Trowel Ranch; station in Morgan County on Burlington and Missouri River Railroad; altitude, 4,158 feet.	
Troy; post village in Las Animas County	Mesa de Maya.
Truesdale; creek in Clear Creek County, a right-hand branch of Bear Creek, tributary to South Platte River	Georgetown.
Trujillo; canyon in Las Animas County, through which flows a tributary of Apishapa River	Spanish Peaks.
Trujillo; post village in Archuleta County.	
Trujillo Plaza; village in Las Animas County	Spanish Peaks.
Trull; post village in Routt County.	
Truro; village in Park County	Pikes Peak.
Tucker; gulch in Jefferson County, tributary to Clear Creek	Blackhawk.
Tucker; mountain in Summit County	Tenmile District Special.
Tumbleson; lake in Boulder County	Boulder.
Tuna; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 6,119 feet.	
Turkey; creek in Eagle County, a left-hand branch of Arkansas River.	

	Atlas sheet.
Turkey; creek in Huerfano County, a left-hand branch of Huerfano River	Huerfano Park.
Turkey; creek in Jefferson County, a right-hand branch of Bear Creek, tributary to South Platte River	Denver.
Turkey; creek in Pueblo County, a left-hand branch of Arkansas River	Pueblo.
Turkey; creek in San Miguel County, a right-hand branch of Lake Fork San Miguel River	Telluride.
Turkey; ridge in Huerfano County; altitude, 6,000 feet	Walsenburg.
Turkey Basin; valley in San Miguel County	Telluride.
Turkeys Roost; summit in Larimer County.	
Turkshead; summit in Jefferson County; altitude, 8,078 feet	Platte Canyon.
Turret; creek in Garfield County, a right-hand branch of Sweetwater Creek, tributary to Grand River.	
Turret; peak in Garfield County.	
Turret; peak in San Juan Mountains, La Plata County; altitude, 13,819 feet	Needle Mountains.
Turret; peak in Rio Blanco County.	
Turret; post village in Chaffee County.	
Turtle; buttes in Pueblo County	Pueblo.
Tuscarora; gulch in Boulder County, tributary to Lefthand Creek	Boulder.
Tuttle; creek in Saguache County, flowing into a sink.	
Tuttle; mountain in San Juan County	Silverton.
Tuttle; post village in Kit Carson County.	
Twelvemile; creek in Park County, a right-hand branch of South Platte River	Leadville.
Twelvemile Park; valley in Fremont County	Pikes Peak.
Twilight; peak in San Juan Mountains, San Juan County; altitude, 13,153 feet	Needle Mountains.
Twin; buttes in Cheyenne County; altitude, 4,608 feet	Kit Carson.
Twin; buttes in Garfield County; altitude, 8,950 feet.	
Twin; buttes in La Plata County	Durango.
Twin; creek in Park and Teller counties, tributary to Lake George	Pikes Peak.
Twin; lakes in Lake County produced by terminal moraines	Leadville.
Twin; mesas forming the south wall of the Black Canyon of the Gunnison; altitude, 9,000 to 10,000 feet.	
Twin Cones; summits in Park County; altitude, 12,400 feet.	
Twin Lakes; post village in Lake County on Denver and Rio Grande Railroad; altitude, 9,015 feet	Leadville.
Twin Sisters; lake in San Juan County; altitude, 13,438 feet	Telluride.
Twin Sisters; summits in San Juan County	Telluride.
Two; buttes in Baca County; altitude, 4,716 feet	Two Butte.
Two Butte; creek in Baca and Las Animas counties, a left-hand branch of Arkansas River.	Mount Carrizo. Two Butte. Albany. Granada.
Two Elk; creek in Eagle County, a left-hand branch of Arkansas River.	
Twomile; canyon in Boulder County, tributary to Boulder Creek	Boulder.

Atlas sheet.

Tyndall; gulch in Custer County, tributary to Silver Run .... Canyon City.
Tyndall mountain in Custer County; altitude, 9,521 feet ..... Canyon City.
Tyne; village in Larimer County.
Tyrone; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,528 feet..... Elmoro.
Ula; village in Custer County.
Ulysses S. Grant; peak in San Miguel County ..... Telluride.
Una; station in Garfield County on Denver and Rio Grande Railroad; altitude, 5,015 feet.
Unagua; spring in Montezuma County; altitude, 8,141 feet.
Unaweep; canyon across Uncompahgre Plateau. It was probably the former course of Grand and Gunnison rivers, which were diverted to their present course by the elevation of this plateau.
Unaweep; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,626 feet.
Unaweep; village in Mesa County.
Uncompahgre; mountains in the northern San Juan group.
Uncompahgre; peak in San Juan Mountains, Hinsdale County; altitude, 14,289 feet..... Lake City.
Uncompahgre; plateau in Montrose and Mesa counties, separating the waters of Dolores and San Miguel rivers from those of the Gunnison. Its crest runs northwest and southeast; altitude, 9,000 to 10,000 feet.
Uncompahgre; post village in Montrose County on Denver and Rio Grande Railroad; altitude, 6,173 feet.
Uncompahgre, river; a left-hand branch of Gunnison River, heading in the northern part of San Juan Mountains and flowing nearly northwest to its mouth.
Uncompahgre; fertile valley of Uncompahgre River.
Uncompahgre Forest Reserve; area 747 square miles.
Uncompahgre Park; valley on the upper waters of Uncompahgre River, at the north base of San Juan Mountains; altitude, 7,500 feet.
Undercliffe; post village in Pueblo County..... Nepesta.
Uneva Lake; station in Summit County on Denver and Rio Grande Railroad.
Unfug; ridge in Huerfano County ..... Walsenburg.
Ungalooroosh; creek in Rio Blanco County, a right-hand branch of White River.
Ungatoowis; creek in Routt and Rio Blanco counties, a right-hand branch of White River.
Union; gulch in Lake County, tributary to Arkansas River... Leadville.
Union; gulch in Summit County, tributary to West Fork Tenmile Creek. Tenmile District Special.
Union; mountain in Summit County; altitude, 12,336 feet.... Tenmile District Special.
Union; station in Fremont County on Florence and Cripple Creek Railroad.
Union; station in Morgan County, on the Burlington and Missouri River and the Union Pacific railroads; altitude, 4,112 feet.

Atlas sheet.

Union Pacific Railroad; system having important lines from Denver north to Cheyenne, Wyo., and east to Kansas City, Mo.
Union Park; valley in Gunnison County; altitude, 9,655 feet.
Union Spur; station on Colorado Midland Railway; altitude, 8,219 feet.
United States Basin; valley in San Juan County ..... Silverton.
University Park; post village in Denver County.
Upham; gulch in Boulder County, tributary to North Boulder Creek ..... Boulder.
Upper Grand Valley; peak in Grand County; altitude, 12,513 feet.
Upper Muddy or Conical; butte in Larimer County; altitude, 9,848 feet.
Upper Park; high mountain valley in La Plata County ..... Needle Mountains.
Uranium; post village in Montrose County.
Urmston; town in Jefferson County.
Utah Junction; station in Arapahoe County, on the Burlington and Missouri River and the Colorado and Southern railroads; altitude, 5,211 feet.
Utaline; station in Mesa County on the Denver and Rio Grande Railway.
Ute; creek, a left-hand branch of Arkansas River.
Ute; creek in Clear Creek County, a left-hand branch of West Chicago Creek, tributary to Chicago Creek ..... Georgetown.
Ute; creek in Costilla Conny, a left-hand branch of Rio Grande ..... Huerfano Park.
Ute; creek in Rio Blanco County, a left-hand branch of White River.
Ute; pass between Summit and Grand counties.
Ute; peak in Grand County; altitude, 11,968 feet.
Ute; (El Late) peak in Montezuma County; altitude, 9,884 feet.
Ute; station in Mesa County on Denver and Rio Grande Railroad; altitude, 4,528 feet.
Ute; village in Huerfano County ..... Walsenburg.
Ute Indian Reservation; in Montezuma County.
Ute Junction; station in La Plata County on Denver and Rio Grande Railroad; altitude, 8,113 feet ..... La Plata.
Ute Park; station in El Paso County on Colorado Midland Railway; altitude, 7,558 feet.
Vacas; river, a right-hand branch of Uncompahgre River.
Vachita; canyon in Las Animas County, tributary to Purgatory River ..... Mesa de Maya.
Vadner; village in Conejos County.
Valdai; village in Larimer County.
Vallecito Basin; valley in La Plata County ..... Needle Mountains.
Vallecito; creek in La Plata County, a left-hand branch of Rio de los Piños ..... Needle Mountains.
Vallecito; post village in La Plata County.
Vallejo; station in La Plata County on Denver and Rio Grande Railroad; altitude, 6,210 feet.
Vallery; station in Morgan County on Burlington and Missouri River Railroad; altitude, 4,449 feet.

Atlas sheet.

Valley; village in Kit Carson County.
Valley View; station in Ouray County on Denver and Rio Grande Railroad.
Vallie; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,322 feet.
Valmont; butte in Boulder County; altitude, 5,394 feet..... Niwot.
Valmont; station in Boulder County on Union Pacific Railroad; altitude, 5,175 feet..... Niwot.
Valverde; post town in Denver County on Colorado and Southern Railway; population in 1900, 665; altitude, 5,221 feet. Denver.
Van Bibber; creek in Jefferson County, a left-hand branch of South Platte River..... Denver.
Van Bremer; arroyo in Las Animas County..... Elmoro.
Vance; creek in Clear Creek County, a left-hand branch of Bear Creek, tributary to South Platte River..... Georgetown.
Vance; creek in San Miguel County, a right-hand branch of Lake Fork San Miguel River..... Telluride.
Vance Junction; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 8,104 feet. Post-office, Vance..... Telluride.
Vanderbilt; town in Ouray County.
Varros, town in Las Animas County.
Vasquez; creek in Grand County, left-hand branch of Frazer River, tributary to Grand River.
Vasquez; peak in Grand County; altitude, 12,658 feet.
Vega; post village in Mesa County.
Vegas; station in Pueblo County on Denver and Rio Grande Railroad; altitude, 4,760 feet.
Velie; peak in Front Range; altitude, 13,456 feet.
Venice; station in Chaffee County on Denver and Rio Grande Railroad; altitude, 8,214 feet.
Verde; post village in Pueblo County; altitude, 5,090 feet.
Verdemont; station in Custer County on Denver and Rio Grande Railroad; altitude, 7,897 feet.
Vermilion; bluffs in Routt County.
Vermilion; creek in Routt County, a left-hand branch of Green River.
Vermilion; peak in San Juan Mountains, San Miguel County; altitude, 13,870 feet..... Telluride.
Vernal; mesa in Montrose County, forming a part of the south wall of the Black Canyon of the Gunnison; altitude, 9,000 feet.
Vernal; station in Montrose County on Denver and Rio Grande Railroad.
Vernon; post village in Yuma County.
Vesta; station in Fremont County on Florence and Cripple Creek Railroad.
Vestal; peak in San Juan Mountains, San Juan County; altitude, 13,846 feet..... Needle Mountains.
Veta; creek in Huerfano County, left-hand branch of Cuchara River, tributary to Huerfano River.
Veta Pass; station in Costilla and Huerfano counties on Denver *and Rio Grande* Railroad; altitude, 9,378 feet..... Huerfano Park.

Atlas sheet.

Veteran; village in Saguache County.
Viceto; village in La Plata County.
Vicksburg; village in Chaffee County.
Victor; pass in Teller County..... Pikes Peak.
Victor; post town in Teller County, on the Colorado Springs and Cripple Creek District, the Florence and Cripple Creek, and the Midland Terminal railways; population in 1900, 4,986; altitude, 9,728 feet..... Pikes Peak.
Victor (Hastings P. O.); city in Las Animas County; population in 1900, 1,174.
Victor Junction; station in Teller County, on the Colorado Springs and Cripple Creek District and the Midland Terminal railways.
Vigil; post village in Las Animas County..... Spanish Peaks.
Vilas; post village in Baca County; altitude, 4,155 feet..... Vilas.
Villa Grove; post town in Saguache County on Denver and Rio Grande Railroad; population in 1900, 103; altitude, 7,962 feet.
Villa Park; town in Denver County.
Vindicator; station in Teller County on Florence and Cripple Creek Railroad.
Vindicator Junction; station in Teller County on Colorado Springs and Cripple Creek District Railway; altitude, 10,220 feet.
Vineland; village in Pueblo County ..... Nepesta.
Violeta; creek in Archuleta County, right-hand branch of Rio Navajo.
Virginia; butte in Gilpin County; altitude, 8,414 feet..... Idaho Springs Special.
Virginia; canyon in Clear Creek County, tributary to Clear Creek. Idaho Springs Special.
Virginia; gulch in La Plata County, tributary to Florida River. Needle Mountains.
Virginia; peak in Front Range, Jefferson county; altitude, 10,600 feet.
Virginia Basin; valley in Gunnison County..... Crested Butte.
Virginia Dale; post village in Larimer County.
Vista Grande; station in Teller County on Florence and Cripple Creek Railroad; altitude, 10,506 feet.
Vivian; gulch in Clear Creek County, tributary to Clear Creek. Idado Springs Special.
Vona; station in Kit Carson County on Chicago, Rock Island and Pacific Railway; altitude, 4,498 feet.
Vulcan; post village in Gunnison County; altitude, 8,190 feet.
Vulcan Crest; in La Garita Hills; altitude, 13,971 feet.
Waddel; creek in Routt County, a left-hand branch of Yampa River.
Wade; gulch in Hinsdale County, tributary to Lake Fork Gunnison River ..... San Cristobal.
Wagon; creek in Costilla County, a left-hand branch of Sangre de Cristo Creek, tributary to Trinchera River..... Huerfano Park.
Wagon Creek Junction; station in Costilla County on Denver and Rio Grande Railroad; altitude, 8,259 feet.

Atlas sheet.

Wagon Wheel Gap; post village in Mineral County; altitude, 8,437 feet.

Wahatoya; creek in Huerfano County, a right-hand branch of Cuchara River. Walsenburg. Spanish Peaks.

Wahatoya; station in Huerfano County on Denver and Rio Grande Railroad; altitude, 6,492 feet.

Wakeman; village in Phillips County.

Walden; post town in Larimer County; population in 1900, 141.

Waldheim; station in San Juan County on Silverton Northern Railroad.

Wales; village in Adams County.

Walker; mountain in Boulder County; altitude, 8,500 feet... Boulder.

Wallet; post village in Kit Carson County.

Wallrock; town in Routt County.

Walls; gulch in La Plata County, tributary to Junction Creek. Durango.

Wallstreet; post village in Boulder County on Colorado and Northwestern Railway; altitude, 6,867 feet..... Boulder.

Walsen; crag in Huerfano County; altitude, 6,500 feet..... Walsenburg.

Walsen; post village in Huerfano County. Railroad name, Loma Junction.

Walsenburg; county seat of Huerfano County, on the Denver and Rio Grande and the Colorado and Southern railroads; population in 1900, 1,033; altitude, 6,187 feet.

Walsenburg Junction; station in Huerfano County, on the Colorado and Southern and the Denver and Rio Grande railroads; altitude, 6,170 feet.

Walton; creek in Routt County, a right-hand branch of Bear River.

Walton; creek in Larimer County, a right-hand branch of Yampa River.

Wanamaker; station in Jefferson County on Colorado and Southern Railway.

Wandell; station in El Paso County on Colorado Midland Railway.

Wapiti; peak in Routt County; altitude, 8,120 feet.

Wapiti; village in Summit County.

Ward; post village in Boulder County on Colorado and Northwestern Railroad; population in 1900, 300; altitude, 9,231 feet.

Warmspring; pass in Park County..... Leadville.

Warren; gulch in Clear Creek County, tributary to Little Bear Creek ..... Georgetown.

Warren; town in Weld County on Union Pacific Railroad.

Warrior; station in Eagle County on Denver and Rio Grande Railroad.

Wasatch; mountain in San Juan Mountains, San Miguel County; altitude, 13,551 feet ..... Telluride.

Washington; county in the northeastern part of the State; bounded on the north by Logan County, on the east by Yuma County, on the south by Lincoln and Kit Carson counties, and on the west by Elbert and El Paso counties. *Its* surface consists of rolling plains. The area is 2,498

Atlas sheet.

Washington—Continued.
square miles. The population in 1900 was 1,241; and of Akron, the county seat, 351. In 1900 the average magnetic declination was 13° 10′ east. The mean annual rainfall is about 14 inches, and the mean annual temperature 50° to 55°.

Washington; gulch in Gunnison County, tributary to Slate River. Crested Butte. Anthracite.

Wason; station in Mineral County on Denver and Rio Grande Railroad; altitude, 8,591 feet.

Water; canyon in Las Animas County, tributary to Purgatory River. Mesa de Maya.

Water; valley in Kiowa County. Cheyenne Wells.

Waterdog; lake in Hinsdale County; altitude, 11,085 feet.

Waterfall; creek in San Miguel County, a left-hand branch of Lake Fork San Miguel River. Telluride.

Waters; station in Teller County on Midland Terminal Railway.

Watervale; station in Las Animas County on Colorado and Southern Railway; altitude, 6,067 feet. Mesa de Maya.

Watkins; station in Adams County on Union Pacific Railroad; altitude, 5,523 feet. Denver.

Watson; post village in Pitkin County on Denver and Rio Grande Railroad; altitude, 7,149 feet.

Waunita; post village in Gunnison County.

Wayside; village in Costilla County.

Weary Mans; creek in Eagle County, a right-hand branch of Eagle River.

Weary Mule; creek in Routt and Rio Blanco counties, a right-hand branch of White River.

Webster; post village in Park County on Colorado and Southern Railway; altitude, 8,000 feet.

Webster Park; elevated tract above the canyon of the Arkansas on the south side of the river; average altitude, 6,800 feet.

Weehawken; creek in Ouray County, a left-hand branch of Canyon Creek, tributary to Uncompahgre River. Ouray.

Weir; village in Sedgwick County; altitude, 3,548 feet.

Weiserhorn; station on Colorado and Southern Railway; altitude, 5,240 feet.

Welba; mountain in Routt County.

Welch; station in Jefferson County on Denver, Lakewood and Golden Railroad.

Weld; county in the extreme northern part of the State; bounded on the north by Wyoming and Nebraska, on the east by Logan and Morgan counties, on the south by Adams County, and on the west by Boulder and Larimer counties. Its surface consists of rolling plains. The area is 3,918 square miles, of which 10 per cent, or 251,307 acres, were under cultivation in 1900. The population in 1900 was 16,808; and of Greeley, the county seat, 3,023. In 1900 the average magnetic declination was 14° 05′ east for the

Atlas sheet.

Weld—Continued.
northeastern part, 13° 25′ east for the northwestern part, and 13° 25′ east for the southwestern part. The mean annual rainfall is about 12 inches, and the mean annual temperature 40° to 45°.

Weldon; station in Morgan County, on Union Pacific Railroad; altitude, 4,341 feet. Post-office, Dawkins.

Wellington; lake in Park County ..... Platte Canyon.

Wellington; post village in Larimer County.

Wellsville; station in Fremont County on Denver and Rio Grande Railroad; altitude, 6,894 feet.

Weminuche; creek in Hinsdale County, a right-hand branch of Rio Piedra, tributary to San Juan River.

Weminuche; pass in San Juan Mountains, Hinsdale County; altitude, 10,622 feet.

Wentz; village in Weld County ..... Greeley.

West; canyon in Las Animas County, through which flows a fork of Purgatory River ..... Spanish Peaks.

West; creek in Douglas and Teller counties, a left-hand branch of Trout Creek, tributary to South Platte River ... Platte Canyon.

West; creek in Mesa County, a right-hand branch of Dolores River, originating in North Fork.

West; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 5,198 feet.

West Beaver; creek in Teller and Fremont counties, a right-hand branch of Beaver Creek, tributary to Arkansas River. Pikes Peak.

West Bijou; creek in Elbert, Arapahoe, and Adams counties, a left-hand branch of Bijou Creek, tributary to South Platte River.

West Brush; creek in Gunnison County, a right hand branch of Cascade Creek, tributary to East River ..... Crested Butte.

West Carrizo; creek in Las Animas County, a right-hand branch of Carrizo Creek, tributary to Cimarron River .... Mount Carrizo.

West Cherry; creek in Douglas County, a left-hand branch of Cherry Creek, tributary to South Platte River ..... Castle Rock.

West Chicago; creek in Clear Creek County, a left-hand branch of Chicago Creek, tributary to Clear Creek ..... Georgetown.

Westcliffe; post town in Custer County on Denver and Rio Grande Railroad; population in 1900, 256; altitude, 7,849 feet ..... Canyon City.

West Colorado Springs; station in El Paso County on Colorado Midland Railway.

West Creek; post town in Douglas County; population in 1900, 161.

West Crow; creek in Weld County, a right-hand branch of Crow Creek, tributary to South Platte River.

West Denver; town in Arapahoe County.

West Elk; creek in Gunnison County, a right-hand branch of Taylor River, tributary to Gunnison River.

West Elk; peak in Elk Mountains, Gunnison County; altitude, 12,920 feet.

West Fork; post village in Montezuma County.

Atlas sheet.

West Fork Miller; creek in Rio Blanco County, a left-hand branch of White River.

West Fourmile; creek in Park and Teller counties, a right-hand branch of Oil Creek, tributary to Arkansas River ... Pikes Peak.

West Glenwood; station in Garfield County, on the Colorado Midland and the Denver and Rio Grande railroads; altitude, 5,741 feet.

West Lake; village in Larimer County.

West Lost Trail; creek in Hinsdale County, a left-hand branch of Rio Grande ..... San Cristobal.

West Mancos; River in Montezuma County, a right-hand branch of Dolores River ..... La Plata.

West Milligan: canyon in Las Animas County, tributary to Purgatory River ..... Spanish Peaks.

West Monument; creek in El Paso County, a right-hand branch of Monument Creek, tributary to Arkansas River.. Colorado Springs.

West Needle; mountains in San Juan Mountains, San Juan and La Plata counties; altitude, 13,050 feet ..... Needle Mountains.

West Newcastle; station in Garfield County on Denver and Rio Grande Railroad; altitude, 5,550 feet.

Weston; gulch in Lake County, tributary to Arkansas River. Leadville.

Weston; pass in Park Range between Park and Lake counties; altitude, 12,109 feet ..... Leadville.

Weston; peak in Park County ..... Leadville.

Weston; post village in Las Animas County; altitude, 6,976 feet.

West Paradox; creek in Montrose County, a left-hand branch of Dolores River.

West Plum; creek in Douglas County, a right-hand branch of Plum Creek, tributary to South Platte River ..... Castle Rock.

West Ranch; village in La Plata County ..... Engineer Mountain.

West Rock; creek in Conejos County, right-hand branch of Rio Conejos.

West Salida; station in Chaffee County on Denver and Rio Grande Railroad.

West Salt; creek in Mesa and Garfield counties, a right-hand branch of Grand River.

Westside; creek in Mesa County, a right-hand branch of Dolores River.

West Silver; mesa in La Plata County ..... Needle Mountains.

West Spanish; peak on boundary between Huerfano and Las Animas counties; altitude, 13,623 feet ..... Spanish Peaks.

West Willow Creek Junction; station in Mineral County on Denver and Rio Grande Railroad.

West Wilson; creek in Fremont County, a right-hand branch of Oil Creek, tributary to Arkansas River ..... Pikes Peak.

Wet; canyon in Las Animas County, through which flows a branch of Purgatory River ..... Spanish Peaks.

Wet; short outlying range of mountains, south of Arkansas River and east of Sangre de Cristo Range ..... Canyon City.

Wetmore; post village in Custer County.

	Atlas sheet.
Wet Mountain; valley lying between Wet Mountains and Sangre de Cristo Range; it is drained mainly by Grape Creek to the Arkansas	Canyon City.
Wet Mountains Forest Reserve; area 374 square miles.	
Wetterhorn; peak in San Juan Mountains on boundary between Hinsdale and Ouray counties; altitude, 14,020 feet	Ouray.
Whale; peak in Park County; altitude, 13,200 feet.	
Wheatland; village in Larimer County; altitude, 5,430 feet.	
Wheatstone; mountain in Elk Mountains, Gunnison County; altitude, 12,548 feet	Crested Butte.
Wheeler; gulch in Summit County, tributary to West Fork Tenmile Creek.	Tenmile District Special.
Wheeler; station in Garfield County on Denver and Rio Grande Railroad; altitude, 6,354 feet.	
Wheeler; station in Summit County on Denver and Rio Grande Railroad; altitude, 9,771 feet.	Tenmile District Special.
Wheelman; village in Boulder County; altitude, 6,318 feet	Boulder.
Whipple; mountain in San Miguel County	Telluride.
White; butte in Pueblo County	Pueblo.
White; creek in Eagle County, a right-hand branch of Turkey Creek, tributary to Arkansas River.	
White; mountain in Garfield County.	
White; river in Rio Blanco County, a left-hand branch of Green River, heading in White River Plateau, in North and South forks, and flowing in a generally western course into eastern Utah.	
White; station in Summit County on Colorado and Southern Railway.	
White; town in Lincoln County.	
Whitecap; mountain in Dolores County	Engineer Mountain.
Whitecross; mountain in Hinsdale County	San Cristobal.
Whitecross; post village in Hinsdale County; altitude, 10,754 feet	San Cristobal.
White Dome; summit in San Juan Mountains, San Juan County; altitude, 13,607 feet	Needle Mountains.
White Earth; creek in Gunnison County, a left-hand branch of Gunnison River.	
White Earth; village in Gunnison County; altitude, 8,163 feet.	
Whiteface; butte in Rio Blanco County; altitude, 7,241 feet.	
Whiteface; peak in Grand County; altitude, 11,494 feet.	
White Fox; creek in Eagle County, a right-hand branch of Eagle River.	
Whitehead; gulch in San Juan County, tributary to Animas River.	Needle Mountains. Silverton.
Whitehead; peak in San Juan County	Silverton.
Whitehead; peak in Routt County; altitude, 10,817 feet.	
Whitehorn; post village in Fremont County.	
Whitehouse; mountain in San Juan Mountains, Ouray County; altitude, 13,496 feet	Ouray.
Whiteley; mountain in Grand County; altitude, 9,848 feet.	
White Park; town in Boulder County.	
White Pillar; summit in Montezuma County.	

Atlas sheet.

White Pine; post village in Gunnison County; population in 1900, 69.

White River; plateau in the northwestern part of the State, containing the headwaters of White River; average altitude, 11,000 to 12,000 feet.

White River; post village in Rio Blanco County, on Colorado Midland Railway.

White River Forest Reserve; area, 1,517 square miles.

White Rock; mountain in Elk Mountains, Gunnison County; altitude, 13,532 feet ..... Crested Butte.

White Rock; station in Boulder County on Union Pacific Railroad; altitude, 5,083 feet ..... Niwot.

Whitewater; creek in Mesa County, a right-hand branch of Gunnison River.

Whitewater; post village in Mesa County on Denver and Rio Grande Railroad; altitude, 4,655 feet.

White Woman; creek in Cheyenne County, a right-hand branch of Walnut Creek, tributary to Arkansas River ..... Cheyenne Wells.

Whitney; peak in Eagle County ..... Leadville.

Wicher; mountain in Park County ..... Pikes Peak.

Widefield; station in El Paso County on Denver and Rio Grande Railroad; altitude, 5,704 feet ..... Colorado Springs.

Wieland; gulch in La Plata County, tributary to La Plata River ..... La Plata.

Wietzer; station in Otero County on Atchison, Topeka and Santa Fe Railway.

Wiggins; post village in Morgan County on Burlington and Missouri River Railroad. Railroad name, Corona.

Wigwam; creek in Park and Jefferson counties, a left-hand branch of South Platte River ..... Platte Canyon.

Wigwam; post village in El Paso County on Denver and Rio Grande Railroad; altitude, 5,220 feet. Railroad name, Henkel ..... Colorado Springs.

Wilbur; post village in Fremont County on Florence and Cripple Creek Railroad; altitude, 8,633 feet ..... Pikes Peak.

Wildcat; creek in Dolores and Montezuma counties, a right-hand branch of East Dolores River ..... Rico.

Wildcat; creek in Gunnison County, a right-hand branch of White Earth Creek, tributary to Gunnison River.

Wildcat; creek in Morgan County, a left-hand branch of South Platte River.

Wildcat; mound in Weld County ..... Greeley.

Wild Cherry; creek in Saguache County, a left-hand branch of San Luis Creek.

Wilde; village in Baca County ..... Two Butte.

Wild Horse; creek in Prowers County, a right-hand branch of Arkansas River ..... Granada.

Wild Horse; creek in Cheyenne County, a left-hand branch of Big Sandy Creek, tributary to Arkansas River. Kit Carson. Arroyo.

Wild Horse; creek in Pueblo County, a left-hand branch of Fountain Creek, tributary to Arkansas River ..... Pueblo.

Wild Horse; peak in San Juan Mountains, Ouray County; altitude, 13,271 feet ..... Ouray.

Atlas sheet.

Wild Horse; post town in Cheyenne County; altitude, 4,453 feet..... Kit Carson.
Wild Horse; station in Chaffee County on Colorado Midland Railway; altitude, 8,064 feet.
Wild Horse Park; valley in Pueblo County..... Pueblo.
Wild Horse Point; summit in Lincoln County..... Arroyo.
Wilkinson, Mount; in Elk Mountains, Gunnison County; altitude, 11,687 feet..... Crested Butte.
Willard; station in Logan County on Burlington and Missouri River Railroad; altitude, 4,345 feet.
Williams; canyon in El Paso County, tributary to Fountain Creek ..... Colorado Springs.
Williams; creek in Larimer County, a left-hand branch of Cache la Poudre River.
Williams; gulch in La Plata County, tributary to La Plata River..... La Plata.
Williams; pass between Chaffee and Gunnison counties.
Williams; peak in Grand County; altitude, 11,413 feet.
Williams; river in Routt and Rio Blanco counties, a branch of Yampa River, heading in South Fork; discharge at Hamilton, May 1 to October 31, 1904, 126,000 acre-feet.
Williamsburg; post town in Fremont County; population in 1900, 337. Post-office, Oak Creek ..... Canyon City.
Williamsburg; village in Boulder County.
Williams River; mountains of the second order in Middle Park separating Blue River from Williams River.
Willis; gulch in Gilpin County, tributary to North Clear Creek. Central City Special.
Willis; station in Conejos County on Denver and Rio Grande Railroad; altitude, 7,574 feet.
Willow; creek in Eagle County, a right-hand branch of Grand River.
Willow; creek in Arapahoe and Douglas counties, a left-hand branch of Little Dry Creek, tributary to South Platte River..... Denver.
Willow; creek in Grand County, a right-hand branch of Grand River.
Willow; creek in Gunnison County, a left-hand branch of Gunnison River..... Lake City.
Willow; creek in Huerfano County, a left-hand branch of Huerfano River ..... Huerfano Park.
Willow; creek in Jefferson County, a left-hand branch of South Platte River ..... Platte Canyon.
Willow; creek in Larimer County, tributary to North Platte River.
Willow; creek in Mineral County, a left-hand branch of Rio Grande.
Willow; creek in Prowers County, a right-hand branch of Arkansas River ..... Lamar.
Willow; creek in Rio Blanco County, a left-hand branch of Piceance Creek, tributary to White River.
Willow; creek in San Miguel County, a right-hand branch of San Miguel River..... Telluride.
Willow; spring in Garfield County.

Atlas sheet.

Willow; spring in Las Animas County ..... Mount Carrizo.
Willow Creek; pass between Larimer and Grand counties; altitude, 9,683 feet.
Willow Park; station in Pitkin County on Crystal River Railroad.
Willow Spring; creek in Fremont County, a right-hand branch of Arkansas River..... Pueblo.
Wilson; creek in Teller and Fremont counties, a left-hand branch of Oil Creek, tributary to Arkansas River..... Pikes Peak.
Wilson; creek in Routt County, a left-hand branch of Yampa River.
Wilson; creek in San Miguel County, a left-hand branch of Lake Fork San Miguel River ..... Telluride.
Wilson; station in San Miguel County on Denver and Rio Grande Railroad; altitude, 7,711 feet. Post-office, Newmire.
Wilson; village in Las Animas County.
Wilson, Mount; in San Juan Mountains, San Miguel County; altitude, 14,250 feet..... Telluride.
Wilson Park; valley in Fremont County..... Pikes Peak.
Winchell; station in Huerfano County on Colorado and Southern Railway; altitude, 6,191 feet.
Wind; mountain in Rio Grande County.
Windom; mountain in San Juan Mountains, La Plata County; altitude, 14,084 feet..... Needle Mountains.
Windsor; town in Weld County on Colorado and Southern Railway; population in 1900, 305; altitude, 4,801 feet. Post-office, New Windsor.
Windy Point; station in Teller County on Colorado Springs and Cripple Creek District Railway.
Windy Point; town in El Paso County.
Winfield; post village in Chaffee County.
Win Held; village in Chaffee County.
Winkfields; station in Dolores County on Denver and Rio Grande Railroad; altitude, 8,893 feet.
Winnebago; hill in Gilpin County ..... Central City Special.
Winnger; gulch in Boulder County, tributary to Beaver Creek ..... Blackhawk.
Winona; village in Larimer County.
Winston; station in Logan County on Burlington and Missouri River Railroad; altitude, 4,151 feet.
Wirick; creek in Custer County, a left-hand branch of Grape Creek, tributary to Arkansas River.
Wolcott; post village in Eagle County on Denver and Rio Grande Railroad; altitude, 6,965 feet.
Wolf; canyon in Las Animas County, tributary to Purgatory River..... Spanish Peaks.
Wolf; creek in Arapahoe County, right-hand branch of Kiowa Creek, tributary to South Platte River.
Wolf; creek in Gunnison County, a right-hand branch of White Earth Creek.
Wolf; creek in Prowers County, a right-hand branch of Arkansas River. Albany. Granada.

Atlas sheet.

Wolhurst; station in Douglas County on Denver and Rio Grande Railroad; altitude, 5,404 feet ..... Denver.
Wolverine Basin; valley in Gunnison County ..... Anthracite.
Wood; mountain in San Juan Mountains, on boundary between Hinsdale and San Juan counties; altitude, 13,640 feet..... Silverton.
Woodchuck; peak in Clear Creek County ..... Georgetown.
Woodchuck Basin; valley in San Juan County ..... Silverton.
Woodcroft; station in Pueblo County on Denver and Rio Grande Railroad.
Woodland; creek in Fremont County, a left-hand branch of Hardscrabble Creek, tributary to Arkansas River..... Canyon City.
Woodland Park; post town in Teller County on Colorado Midland Railway; population in 1900, 269; altitude, 8,479 feet..... Pikes Peak.
Woodruff; station in Fremont County on Atchison, Topeka and Santa Fe Railway; altitude, 4,952 feet.
Woodstock; station in Gunnison County on Colorado and Southern Railway; altitude, 11,028 feet.
Woody; creek in Pitkin County, a right-hand branch of Roaring Fork, tributary to Grand River..... Aspen.
Woody; village in Pitkin County on Denver and Rio Grande Railroad..... Aspen.
Woody Creek; station in Pitkin County on Denver and Rio Grande Railroad; altitude, 7,260 feet.
Wootton; station in Las Animas County on Atchison, Topeka and Santa Fe Railway; altitude, 7,534 feet.
Work; station in Teller County on Colorado Springs and Cripple Creek District Railway.
Worm; spring in Fremont County.
Wortman; post village in Lake County.
Wray; county seat of Yuma County on Burlington and Missouri River Railroad; population in 1900, 271; altitude, 3,531 feet.
Wrights; spring in San Miguel County.
Wylies; station in Gunnison County on Colorado and Southern Railway.
Wynetka; station in Jefferson County on Colorado and Southern Railway; altitude, 5,366 feet..... Denver
Xenia; station in Washington County on Burlington and Missouri River Railroad; altitude, 4,549 feet.
Yale, Mount; in Sawatch Range, Chaffee County; altitude, 14,187 feet.
Yale; post village in Kit Carson County.
Yale; station in Chaffee County on Colorado Midland Railway; altitude, 8,683 feet.
Yampa; canyon in Routt County on the lower course of Yampa River.
Yampa; peak in Routt County; altitude, 8,022 feet.
Yampa; plateau between Yampa and White rivers, extending westward into Utah, where it is cut through by Grand River; altitude, nearly 9,000 feet.
Yampa; post village in Routt County.

Atlas sheet.

Yampa; river in Routt County, a left-hand branch of Green River, heading in the western slopes of Park Range and flowing in a generally western course to its mouth; discharge near Maybell, April 17 to October 31, 1904, 816,900 acre-feet.

Yankee; hill in Lake County ..... Leadville.

Yankee; post village in Clear Creek County.

Yankee Bar; mining town in Gilpin County ..... Blackhawk.

Yankee Girl; town in Ouray County.

Yeiser; post town in Las Animas County.

Yellow; mountain in San Miguel County ..... Telluride.

Yellow Jacket; pass in Rio Blanco County; altitude, 7,493 feet.

Yellow Jacket; spring in Montezuma County.

Yellowstone; gulch in Hinsdale County, tributary to North Fork Henson Creek ..... Lake City.

Yoder; town in El Paso County.

Yorkville; village in Fremont County ..... Canyon City.

Youman; station in Gunnison County on Denver and Rio Grande Railroad; altitude, 8,311 feet ..... Lake City.

Yoxall; station in Weld County on Union Pacific Railroad.

Yuma; post town in Yuma County on Burlington and Missouri River Railroad; population in 1900, 139; altitude, 4,147 feet.

Yuma; county in the eastern part of the State; bounded on the north by Phillips County, on the east by Kansas and Nebraska, on the south by Kit Carson County, and on the west by Washington County. The surface consists of rolling plains. Its area is 2,316 square miles. The population in 1900 was 1,729; and of Wray, the county seat, 271. In 1900 the average magnetic declination was 13° 00′ east. The mean annual rainfall is about 16 inches, and the mean annual temperature 50° to 55°.

Zapata; village in Costilla County; altitude, 7,562 feet.

Zenobia; peak in Routt County; altitude, 9,297 feet.

Zinc Junction; station in Pueblo County on Denver and Rio Grande Railroad.

Zion, Mount; in Lake County ..... Leadville.

Zirkel; post village in Larimer County.

Zirkel, Mount; in Larimer County; altitude, 12,126 feet.

Zuni; gulch in San Juan County, tributary to South Fork Animas River ..... Silverton.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 291.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States—folios and separate sheets thereof; (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are delivered to Senators and Representatives in Congress, for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at prices slightly above cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the fifty-first in Series F, the complete list of which follows (all are bulletins thus far except Professional Paper 45):

SERIES F, GEOGRAPHY.

5. Dictionary of altitudes in United States, by Henry Gannett. 1884. 325 pp. (Out of stock; see Bulletin 274.)
6. Elevations in Dominion of Canada, by J. W. Spencer. 1884. 43 pp. (Out of stock.)
13. Boundaries of United States and of the several States and Territories, with historical sketch of territorial changes, by Henry Gannett. 1885. 135 pp. (Out of stock; see Bulletin 226.)
48. On form and position of sea level, by R. S. Woodward. 1888. 88 pp. (Out of stock.)
49. Latitudes and longitudes of certain points in Missouri, Kansas, and New Mexico, by R. S. Woodward. 1889. 133 pp.
50. Formulas and tables to facilitate the construction and use of maps, by R. S. Woodward. 1889. 124 pp. (Out of stock.)
70. Report on astronomical work of 1889 and 1890, by R. S. Woodward. 1890. 79 pp.
72. Altitudes between Lake Superior and Rocky Mountains, by Warren Upham. 1891. 229 pp.
76. Dictionary of altitudes in United States (second edition), by Henry Gannett. 1891. 393 pp. (Out of stock; see Bulletin 274.)
115. Geographic dictionary of Rhode Island, by Henry Gannett. 1894. 31 pp. (Out of stock.)
116. Geographic dictionary of Massachusetts, by Henry Gannett. 1894. 126 pp. (Out of stock.)
117. Geographic dictionary of Connecticut, by Henry Gannett. 1894. 67 pp. (Out of stock.)
118. Geographic dictionary of New Jersey, by Henry Gannett. 1894. 131 pp. (Out of stock)
122. Results of primary triangulation, by Henry Gannett. 1894. 412 pp., 17 pls. (Out of stock.)
123. Dictionary of geographic positions, by Henry Gannett. 1895. 183 pp., 1 map. (Out of stock.)
154. Gazetteer of Kansas, by Henry Gannett. 1898. 246 pp., 6 pls.

160. Dictionary of altitudes in United States (third edition), by Henry Gannett. 1899. 775 pp. (Out of stock; see Bulletin 274.)
166. Gazetteer of Utah, by Henry Gannett. 1900. 43 pp., 1 map.
169. Altitudes in Alaska, by Henry Gannett. 1900. 13 pp.
170. Survey of boundary line between Idaho and Montana from international boundary to crest of Bitterroot Mountains, by R. U. Goode. 1900. 67 pp., 14 pls.
171. Boundaries of United States and of the several States and Territories, with outline of history of all important changes of territory (second edition), by Henry Gannett. 1900. 142 pp., 58 pls. (Out of stock; see Bulletin 226.)
174. Survey of northwestern boundary of United States, 1857–1861, by Marcus Baker. 1900. 78 pp., 1 pl.
175. Triangulation and spirit leveling in Indian Territory, by C. H. Fitch. 1900. 141 pp., 1 pl.
181. Results of primary triangulation and primary traverse, fiscal year 1900-1901, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1901. 240 pp., 1 map.
183. Gazetteer of Porto Rico, by Henry Gannett. 1901. 51 pp. (Out of stock.)
185. Results of spirit leveling, fiscal year 1900–1901, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1901. 219 pp.
187. Geographic dictionary of Alaska, by Marcus Baker. 1901. 446 pp. (Out of stock.)
190. Gazetteer of Texas, by Henry Gannett. 1902. 162 pp., 8 pls. (Out of stock.)
192. Gazetteer of Cuba, by Henry Gannett. 1902. 113 pp., 8 pls. (Out of stock.)
194. Northwest boundary of Texas, by Marcus Baker. 1902. 51 pp., 1 pl.
196. Topographic development of the Klamath Mountains, by J. S. Diller. 1902. 69 pp., 13 pls.
197. The origin of certain place names in the United States, by Henry Gannett. 1902. 280 pp. (Out of stock; see Bulletin 258.)
201. Results of primary triangulation and primary traverse, fiscal year 1901–2, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1902. 164 pp., 1 pl.
214. Geographic tables and formulas, compiled by S. S. Gannett. 1903. 284 pp. (Out of stock; see Bulletin 234.)
216. Results of primary triangulation and primary traverse, fiscal year 1902–3, by S. S. Gannett. 1903. 222 pp., 1 pl.
224. Gazetteer of Texas (second edition), by Henry Gannett. 1904. 177 pp., 7 pls.
226. Boundaries of the United States and of the several States and Territories, with an outline of the history of all important changes of territory (third edition), by Henry Gannett. 1904. 145 pp., 54 pls.
230. Gazetteer or Delaware, by Henry Gannett. 1904. 15 pp.
231. Gazetteer of Maryland, by Henry Gannett. 1904. 84 pp.
232. Gazetteer of Virginia, by Henry Gannett. 1904. 159 pp.
233. Gazetteer of West Virginia, by Henry Gannett. 1904. 164 pp.
234. Geographic tables and formulas (second edition), compiled by S. S. Gannett. 1904. 310 pp.
245. Results of primary triangulation and primary traverse, fiscal year 1902–3, by S. S. Gannett. 1904. 328 pp., 1 pl.
248. Gazetteer of Indian Territory, by Henry Gannett. 1904. 70 pp.
258. The origin of certain place names in the United States (second edition), by Henry Gannett. 1905. 334 pp.
Professional Paper 45. The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. 1906. 327 pp., 34 pls.
274. A dictionary of altitudes in the United States (fourth edition), compiled by Henry Gannett. 1906. 1072 pp.
276. Results of primary triangulation and primary traverse, fiscal year 1904–5, by S. S. Gannett. 1905. 263 pp., 1 pl.
281. Results of spirit leveling in the State of New York for the years 1896 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 112 pp.
288. Results of spirit leveling in Pennsylvania for the years 1899 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 62 pp.
291. Gazetteer of Colorado, by Henry Gannett. 1906. 185 pp.

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THE DIRECTOR,
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Bulletin No. 292 Series C, Systematic Geology and Paleontology, 78

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE BRYOZOAN FAUNA OF THE ROCHESTER SHALE

BY
RAY S. BASSLER

WASHINGTON
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THE BRYOZOAN FAUNA OF THE ROCHESTER SHALE.[a]

By RAY S. BASSLER.

INTRODUCTION.

As compared with the other Paleozoic systems affording bryozoa, the Silurian, with the exception of the Helderbergian [b] group, has received least attention. Ulrich has elucidated the bryozoa of the Ordovician and Carboniferous systems particularly in several important monographs, while Hall and Simpson have summed up their papers on this class in Volume VI of the Paleontology of New York, where they have given a comprehensive idea of the many beautiful forms found in the Devonian. However, it can not be said that the bryozoa of any of the Silurian formations have been totally neglected, as a number of publications touch on them. Still, few authors have attempted to work out a fauna in detail. As early as 1852 Professor Hall published fairly complete accounts of the faunas of the Clinton and Niagara of New York, and in 1876 he gave descriptions and figures of the fine assemblage of species found at the noted Niagaran locality, Waldron, Ind. The bryozoa, as well as the other classes, were well represented in these faunas, but, on account of the inadequate methods then used in discriminating specific and generic types, Professor Hall's work needs revision.

Instead of reviewing the Silurian faunas in their geologic order, a study of the species of the Rochester shale has been undertaken first, because the most complete collections that the writer has had the opportunity of studying are from this formation. Since the number of species here is also apparently larger than in any other Silurian horizon, this paper can be used as the basis for comparative remarks in future articles.

Through the kindness of Mr. B. E. Walker, of Toronto, Canada, the writer has been enabled to study the collection made in the vicinity of Grimsby, Ontario, by the late Mr. Pettit. This is a most excellent collection of fossils from the Rochester shale and contains several of the types figured in this paper. A fine collection from Rochester, N. Y., was loaned by Mr. Z. F. Westervelt. Mr. Clifton J. Sarle presented a good series of bryozoa from the same region. Dr. A. W. Grabau loaned all of the material collected by him during his study of the Niagara region. Prof. R. P. Whitfield loaned the Hall types in the American Museum of Natural History. Prof. J. F. Whiteaves sent many Canadian specimens for examination. To all these gentlemen the writer wishes to express his obligations for their generous help. The paleontologic collections of the United States National Museum are rich in Niagara bryozoa and contain, with a few exceptions, all of the material described and figured here. These collections were made at various times by Mr. G. T. McComb, of Lockport, N. Y.; Messrs. E. O. Ulrich, H. E. Dickhaut, and J. M. Nickles, of the United States Geological Survey; Prof. Charles Schuchert, of Yale University; and the writer.

[a] Published by permission of the Assistant Secretary of the Smithsonian Institution.

[b] Throughout this paper the group names used follow the New York classification recently proposed by Messrs. Clarke and Schuchert, although these terms have not been officially adopted by the United States Geological Survey.

Unless otherwise designated, the photographs illustrating this paper were made in the laboratory of the United States National Museum and the drawings are the work of the writer.

From the amount of material studied, the bryozoan fauna of these shales is believed to be represented here with some degree of completeness.

GENERAL DISTRIBUTION OF SILURIAN BRYOZOA.

The Silurian bryozoa as a whole have a facies quite distinct from the preceding and succeeding systems. When they are compared with the Ordovician types, the noticeable features are the predominance of the Cryptostomata and the decline of the Trepostomata. The Cyclostomata continue to hold their own, while the Ctenostomata and Chilostomata, as in all the other Paleozoic systems, have few representatives. In the Devonian the Cryptostomata still predominate, the Cyclostomata have been greatly augmented by species of the Fistuliporidæ, and the Trepostomata, still further reduced in number of species, are represented mainly by genera of the long-enduring Batostomellidæ.

Conditions during Oswegan times were in general so unfavorable for the preservation of fossils that it is not surprising that few bryozoa are known from these rocks. The same conditions, with a slight modification, existed in the Medina, where, however, a small bryozoan fauna is known but is as yet unpublished. This consists of a few species of Trepostomata and Cryptostomata which have been found in the more calcareous strata of the formation.

The Clinton and Rochester divisions of the Niagaran group afford species and specimens of this class in great abundance, but in the succeeding Lockport and Guelph divisions the bryozoa are comparatively rare. In New York and Ontario the thin limestone layers of the Clinton are often crowded with *Helopora fragilis* and several species of *Phænopora*, these being the characteristic bryozoa in this region. In Ohio the Clinton beds contain a considerable number of species, but the predominating forms are *Rhinopora verrucosa*, species of *Pachydictya* and *Phænopora*, and a few large ramose Trepostomata, some of which seem to be wanting in the East. The unusual development of the genus *Phænopora* is the striking feature of Clinton time. During the deposition of the Rochester shale, ideal conditions for the development of bryozoa seem to have been reached. Near the middle part of this formation occurs a stratum several feet in thickness that is literally one mass of fragments of these organisms. The correlation of these shales with the Osgood beds in the Indiana Niagaran section and their faunal similarity to the Buildwas beds of the Wenlock of England is discussed later in this paper. As already stated, bryozoa are apparently rarely found in the Lockport and Guelph divisions of the Niagaran.

The Salina and Rondout (Bertie) formations of the Cayugan group were deposited under conditions unsuited to bryozoan life. During the time of the last formation of this group, the Manlius, conditions more favorable to the life of the class returned, a fauna of fifteen or twenty species being known. This will be described by Mr. E. O. Ulrich and the writer in a forthcoming volume of the Maryland Geological Survey.

The various formations of the Helderberg again, especially the New Scotland, are rich in bryozoa. Most of these have been described and illustrated by Hall and Simpson in Volume VI of the Paleontology of New York. Although this series of rocks is referred by some authors to the Devonian, the similarity of its bryozoan fauna to that of the Niagaran is so great that the writer can not see that its position should be other than in the Silurian.

GENERAL DISCUSSION OF THE ROCHESTER SHALE AND ITS BRYOZOAN FAUNA.

Succeeding the Clinton in western New York and Ontario is a shale, which on account of its prominence along Genesee River at Rochester, N. Y., was termed the Rochester shale. In the Niagara region this shale has a thickness of about 70 feet and is divisible into a lower and an upper half. The lower half is generally highly fossiliferous and contains numerous

UPPER FALLS OF GENESEE RIVER, ROCHESTER, N. Y.

Photograph by Webster & Albee.

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limestone bands, especially toward the top, which is formed by a bed about 4 feet thick that is extremely rich in bryozoa. This bed has afforded most of the bryozoa described in this paper. The limestone layers are often composed almost entirely of fragmentary bryozoa cemented together. The upper division of the shales is less calcareous and much less fossiliferous than the lower. It also contains a very different fauna, the prevailing species being pelecypods, ostracods, and trilobites. Toward the top of this division fossils become still rarer and seem to disappear altogether as the basal layers of the overlying Lockport dolomite are reached.

Since the publication in 1852 of Volume II of the Paleontology of New York, the bryozoa of the Rochester shale have received little attention. At that time Professor Hall described a large number of species from the classic locality, Lockport, N. Y. This work was remarkably well done for that date and the methods of study then followed. In the majority of instances the student has little difficulty in identifying the various species. About a third of a century later Mr. E. N. S. Ringueberg added a few new species to the described fauna. These two men are the authors of practically all the forms so far described as originally from this shale. However, neither of them studied the internal characters of their species nor gave definite measurements to any extent, and since the correct generic identification depends on internal rather than external features further work on the fauna is desirable. It is, therefore, the object of this paper to figure and describe the known species, as well as new forms, using modern methods of description.

The Niagara escarpment of western New York and Ontario furnishes numerous localities where natural exposures show the fossiliferous shale. In the vicinity of Lockport, N. Y., the two "gulfs," which indent the escarpment, afford excellent collecting ground, and here, especially in the vicinity of the Erie Canal, much of the material on which this paper is based was procured. Especially fine slabs and washings were obtained in the vicinity of the pulp mills along the Erie Canal. The beautiful preservation and the variety of specimens upon these slabs are brought out in Pls. XXVIII to XXX. At Lockport and localities in western New York in general, the specimens weather out in an excellent state of preservation, so far as external characters are concerned, but on account of the presence of iron pyrites in the shales the internal features are sometimes destroyed.

At Rochester, N. Y., the type locality of the shale, a different style of preservation obtains. In the examples found here the internal features are sometimes obscured by a slight silicification, and caustic potash must be used freely on the specimens to remove the clay, which often obscures the exterior features. Washings containing many or good free specimens are seldom to be found at Rochester, and the thin limestone layers, although containing numerous fossils, are generally so covered with a hard clay that caustic potash is necessary to expose them. At Middleport, N. Y., the limestone layers are sometimes made up almost exclusively of fragmentary bryozoa in an excellent state of preservation, as is shown by the small slab figured in Pl. III.

In the Niagara Gorge[a] the banks and railroad cuts afford a few good exposures, where the bryozoa-bearing shale is well exposed, and as a result a considerable number of species may be found. Here the preservation is essentially the same as at Lockport. The Silurian section is best seen on the American side along the cuts of the New York Central and Hudson River Railroad. The strata dip southward, while the railroad rises in the same direction, with the result that the various formations are crossed in ascending order going toward the Falls. In making the railroad cut, several mounds were left which now form good collecting ground. One of these mounds is on a level with the bryozoan bed, and here numerous specimens may be had. At most places along the gorge, however, the Rochester shale, although well exposed, is inaccessible, as is shown in Pl. II, facing page 4.

In Ontario the principal localities from which bryozoa were obtained for study are Grimsby, Hamilton, and Thorold. Here the Rochester shales become somewhat sandy

[a] The geology of this vicinity has been well described and illustrated by Doctor Grabau in his "Guide to the Geology and Paleontology of Niagara Falls and Vicinity" (Bull. New York State Museum, No. 45, 1901), to which the reader is referred for a more complete discussion.

and the surface characters of the fossils are not so well preserved. However, this is compensated for by the excellent preservation of their internal features. A considerable fauna was determined from the extensive collections made by Mr. Pettit at Grimsby, Ontario.

COLLECTING IN THE ROCHESTER SHALE.

The Rochester shale affords ideal localities for collecting by the process of washing. The shale immediately above or below the fossiliferous limestone bands almost invariably on washing yields free specimens of the species found upon the slabs. Still better results are obtained if the fossiliferous limestone layer be traced until it changes into a marl or clay, as often happens, for here the fossils ordinarily helping to make up the limestone are more complete, and being uncemented can be washed out free. Careful selection of clay from such marly pockets or from above or below unusually rich limestone layers will yield excellent fossils and save time in the picking out of the specimens after the material has been washed.

In washing fossiliferous shale the writer has found that the best method to obtain the specimens in as perfect condition as possible is first to spread out the material and expose it to the sun for a day or more. When the clays have been weathered in the field, this, of course, is unnecessary. Such an exposure slakes the clay, allows the specimens to dry, and thus become less liable to break, and, moreover, causes the clay to disintegrate more readily. Then if the marl or clay be allowed to soak for a day, the final washing is a short and simple matter, consisting merely in allowing clear water to run over the material until the water passes through without becoming discolored. After the residue has dried, sifting the material into several grades of fineness will aid in assorting the specimens. This method of washing has the advantage of reducing the breaking of the specimens to a minimum, for in the ordinary process the shaking required to hasten the disintegration of the clay breaks or otherwise injures the more delicate fossils.

After washing a sample of fossiliferous Rochester shale it will be found to consist almost entirely of fossil remains. The coarse material is composed largely of fragmentary or entire specimens of brachiopods, crinoidal remains, and ramose or massive bryozoa. In searching for bryozoa, the fragmentary brachiopods and crinoidal remains should be carefully examined, for they are often incrusted by delicate, parasitic species, especially of the Ctenostomata. In washings from certain localities near Lockport, one out of every three or four fragments of *Spirifer niagarensis* was incrusted by the unique bryozoan *Rhopalonaria attenuata*. The finer material usually shows an abundance of the small ramose and fenestrated bryozoa and of young specimens of brachiopods, while the finest siftings afford ostracods and other microscopic organisms.

In England the strata corresponding to the Rochester have been thoroughly searched for fossils by washing, and a large and interesting fauna is the result. Unfortunately little has been published concerning the bryozoa obtained from these washings, but the numerous ostracods described by Jones and Holl and the brachiopods described by Davidson show the value of this method of collecting. Mr. Maw's washings are well known to every student of the Wenlock. Over 20 tons of these shales were washed by him for fossils. The number of specimens picked out ran into the thousands for some of the species. The Rochester shale compares quite as favorably in this respect, since from the residue of 50 pounds of shale so treated the writer picked out over 5,000 specimens of the bryozoan *Chilotrypa ostiolata*, while other small ramose species, such as *Acanthoclema asperum* and *Batostomella granulifera* would be found to occur in the same abundance if one should take the trouble to assort all of the specimens. If 20 tons of this shale were washed, the specimens of at least some of these species would have to be recorded by quantity rather than by number.

Sometimes the fossils of the Rochester are confined entirely to the limy layers. In this case if free specimens are desired many of them may be detached from the slabs without injury by means of caustic potash. Entire zoaria, or even average specimens of such fragile forms as the Phylloporinidæ or Fenestellidæ, can be had only on slabs of limestone or shale. *The washings will yield* small, clean fragments of these for study, but no large, showy *examples for exhibition.*

NIAGARA GORGE BELOW THE SUSPENSION BRIDGE, NIAGARA COUNTY, N. Y.

From the Canadian side. Photograph by I. P. Bishop.

CORRELATION.

For various reasons the exact correlation of the several members of the New York Niagaran with strata of the same age elsewhere has not met with complete satisfaction. The lithologic and faunal differences in beds which should apparently be correlated stratigraphically are so great that it seems evident for these reasons alone that the rocks must have been deposited in separate basins. For lack of sufficient collections the evidence afforded by the bryozoa in the correlation of the various Niagaran deposits is not yet complete, but the present study of the Rochester shale fauna and of collections from the Osgood beds of Indiana indicates the undoubted equivalence of at least these two formations.

The Niagaran strata exposed along the western flank of the Cincinnati anticline in southern Indiana, Kentucky, Tennessee, and northern Alabama have been divided into the following formations:[a]

5. Louisville limestone.
4 Waldron shale.
3. Laurel limestone.
2. Osgood shale and limestone.
1. Clinton limestone.

The distribution and paleontological characteristics of these rocks have been discussed by Foerste in various articles, and the following description of the Osgood formation is based mainly on his work:

Several thin limestone layers having a total thickness of 8 to 15 inches form the base of the Osgood formation. Following these are 11 to 16 feet of clay, which in Kentucky is usually soft, but in Indiana is somewhat indurated. In other sections this lower Osgood clay is overlain by a crinoidal limestone often 5 feet in thickness, and this in turn by the upper Osgood clay variable in thickness but sometimes reaching 5 feet.

According to Foerste, *Pisocrinus*, *Stephanocrinus*, *Holocystites*, *Rhynchotreta*, *Spirifer*, *Cyrtia*, and *Nucleospira* make their first appearance in the Osgood formation. Associated with these, especially in the clayey partings of the limestones, are the bryozoa identified in this paper. Most all of the nonbryozoan genera and in fact identical species even may occur in the Rochester shale. The evidence presented by the bryozoa themselves is shown in the table below.

In regard to the correlation of the Osgood fauna, Foerste[b] remarks as follows: "In many respects the Osgood fauna is a forerunner of that found in the Waldron. It corresponds to the reef fauna at the top of the Clinton of New York, where it occurs in the limestones exposed in the lens-like cross sections just beneath the Rochester shale."

While the writer agrees that the Osgood fauna is a forerunner of the Waldron, and that it also may correspond in part to the reef fauna, comparisons of the bryozoan elements of the faunas seem to show beyond question that the Osgood is chiefly if not exactly comparable with the Rochester shale.

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[a] Foerste, A. F., Twenty-eighth Ann. Rept. Indiana Dept. Geol. Nat. Res., 1904.
[b] Op. cit., p. 30.

The following list of Rochester shale species, showing their distribution, indicates the identity of forms in the two areas:

Alphabetic list of bryozoa in Rochester shale, showing range and comparative abundance.

[r=rare; u=uncommon; c=common.]

	Western New York.	Ontario.	Osgood beds, Indiana.	Waldron beds, Indiana.
Acanthoclema asperum (Hall)	c	c	u	.....
Allonema waldronense Ulrich and Bassler	r	.....	.....	r
Ascodictyon siluriense Vine	r	.....	.....	r
Batostomella granulifera (Hall)	c	c	u	.....
Berenicea consimilis (Lonsdale)	u	r	r	r
Bythopora spinulosa (Hall)	c	c	.....	.....
Callopora clausa n. sp	u	u	c	.....
Callopora elegantula Hall	c	c	c	c
Callopora magnopora Foerste	r	r	.....	.....
Ceramopora imbricata Hall	u	u	c	.....
Ceramopora niagarensis n. sp	u	u	u	.....
Ceramoporella irregularis n. sp	r	.....	.....	.....
Ceramoporella orbiculata (Ringueberg)	u	u	.....	.....
Chilotrypa ostiolata (Hall)	c	c	c	.....
Clathropora alcicornis Hall	r	.....	.....	.....
Clathropora frondosa Hall	u	u	.....	.....
Clathropora frondosa intermedia Nicholson and Hinde	u	u	.....	.....
Cœloclema cavernosa n. sp	r	.....	r	.....
Diamesopora dichotoma, Hall	c	c	.....	.....
Diploclema sparsum (Hall)	c	c	.....	.....
Diploclema sparsum argutum n. var	u	.....	.....	.....
Diplotrypa walkeri n. sp	.....	u	.....	.....
Eridotrypa nodulosa n. sp	u	.....	.....	.....
Eridotrypa similis n. sp	u	u	.....	.....
Eridotrypa solida (Hall)	c	c	.....	.....
Eridotrypa spinosa n. sp	u	u	c	.....
Eridotrypa striata (Hall)	c	c	c	.....
Fenestella cribrosa Hall	u	.....	.....	.....
Fenestella elegans Hall	c	c	.....	.....
Fistulipora crustula n. sp. or n. name	c	c	.....	.....
Fistulipora laminata (Hall)	u	u	.....	.....
Fistulipora lockportensis n. sp	u	.....	.....	.....
Fistulipora tuberculosa (Hall)	u	u	.....	.....
Idiotrypa punctata (Hall)	c	c	u	.....
Lichenalia concentrica Hall	u	u	.....	.....
Lioclema asperum (Hall)	c	c	c	.....
Lioclema circinctum n. sp	r	.....	.....	.....
Lioclema explanatum n. sp	c	.....	r	.....
Lioclema globulare n. sp	r	.....	.....	.....
Lioclema multiporum n. sp	c	c	u	.....
Lioclema peculiare n. sp	u	u	r	.....
Lioclema ramulosum n. sp	u	u	u	.....
Lioclemella maccombi n. sp	c	c	r	.....
Loculipora ambigua precursor n. var	r	.....	r	.....
Loculipora ulrichi n. sp	c	c	.....	.....
Meekopora foliacea (Hall)	u	u	.....	.....
Mesotrypa nummiformis (Hall)	u	u	u	.....
Mitoclema sarlei n. sp	c	.....	.....	.....
Monotrypa benjamini n. sp	c	c	c	.....
Monotrypa osgoodensis n. sp	c	c	c	.....

Alphabetic list of bryozoa in Rochester shale, showing range and comparative abundance—Continued.

	Western New York.	Ontario.	Osgood beds, Indiana.	Waldron beds, Indiana.
Monotrypa pediculata n. sp	u	u	u	.....
Nematopora minuta (Hall)	c	c	.....	u
Nicholsonella florida (Hall)	c	c	u	.....
Nicholsonella ringuebergi n. sp	r	.....	.....	.....
Orbignyella expansa (Ringueberg)	u	u	.....	.....
Orbignyella magnopora n. sp	u	u	.....	.....
Pachydictya crassa (Hall)	c	c	c	c
Phænopora ensiformis Hall	u	u	u	.....
Phænopora fimbriata canadensis n. var	r	r	.....	.....
Phylloporina asperato-striata (Hall)	c	c	u	.....
Polypora incepta Hall	c	c	.....	.....
Pseudohornera diffusa (Hall)	r	r	.....	.....
Pseudohornera niagarensis (Hall)	u	u	.....	u
Ptiloporella nervata (Nicholson)	u	u	r	.....
Rhinopora curvata Ringueberg	r	r	.....	.....
Rhombotrypa spinulifera n. sp	u	u	u	.....
Rhopalonaria attenuata Ulrich and Bassler	c	c	.....	u
Semicoscinium tenuiceps (Hall)	c	c	r	.....
Spatiopora maculata (Hall)	u	u	.....	u
Stictotrypa punctipora (Hall)	c	c	.....	.....
Stigmatella globata n. sp	u	.....	.....	.....
Stomatopora dissimilis Vine	u	u	r	r
Stomatopora elongata Vine	r	.....	.....	r
Tæniodictya schucherti n. sp	r	r	.....	.....
Thamniscus dichotomus (Hall)	c	c	.....	.....
Trematopora spiculata Hall	c	c	r	c
Trematopora tuberculosa Hall	c	c	u	.....
Trematopora whitfieldi Ulrich	u	u	.....	c
Vinella ? multiradiata Ulrich and Bassler	r	.....	.....	.....
Vinella radiciformis (Vine)	r	r	.....	r

By comparing the species in this list it will be seen that of the 80 forms recorded in the Rochester shale 33 occur also in the Osgood beds and but 14 in the Waldron beds. Since the Waldron shale has been much more thoroughly searched for bryozoa than the Osgood beds, these figures are significant. It is further to be borne in mind that, since most of the Rochester shale species that are known in Indiana as yet only in the Waldron are almost world-wide in their distribution, more complete collections from the Osgood beds may be confidently expected to materially increase the already large number of species which these beds hold in common with the Rochester shale. For this reason the foregoing tabular comparison is not entirely competent Perhaps the surest way of testing the contemporaneity of the Rochester and Osgood bryozoan faunas is by means of lists from which species known to be of wide range, as well as those common to the Rochester and the Waldron, are excluded. Such lists may fairly be said to comprise, so far as known, only the characteristic species of the Rochester, though not all of them.

Partial list of characteristic Rochester and Osgood bryozoa.

Acanthoclema asperum.
Batostomella granulifera.
* Bythopora spinulosa.
Callopora clausa.
Ceramopora imbricata.
Ceramopora niagarensis.
Chilotrypa ostiolata.
* Diamesopora dichotoma.
* Diploclema sparsum.
Eridotrypa spinosa.
* Eridotrypa solida.
Eridotrypa striata.
* Fenestella elegans.
* Fistulipora crustula.
Idiotrypa punctata.
* Lichenalia concentrica.
Lioclema asperum.
Lioclema explanatum.
Lioclema multiporum.
Lioclema peculiare.
Lioclema ramulosum.
Lioclemella maccombi.
Loculipora ambigua var. precursor.
* Loculipora ulrichi.
* Meekopora foliacea.
Mesotrypa nummiformis.
* Mitoclema sariei.
Monotrypa benjamini.
Monotrypa osgoodensis.
Monotrypa pediculata.
Nicholsonella florida.
Phylloporina asperato-striata.
* Polypora incepta.
Rhombotrypa spinulifera.
* Stictotrypa punctipora.
* Thamniscus dichotomus.
Trematopora tuberculosa.

Of the above list of 37 species, those marked with an asterisk appear to be limited to the Rochester shale. The remaining 24 species, or about 65 per cent, are common to the Rochester shale and the Osgood beds. After weeding out the wide-ranged (European and American) species from those shown in the main list to be common to the Rochester and the Waldron shales, only 7 species remain to be set against the 24 in the Osgood beds, and of this residue 3 species, viz, *Callopora elegantula*, *Pachydictya crassa*, and *Trematopora spiculata*, occur in all three beds. The evidence in favor of the equivalence of the Osgood and Rochester is further strengthened by the fact that while practically all of the known Osgood bryozoa occur also in the Rochester, the Waldron, on the contrary, contains many that are unknown in that formation.

The Wenlock shales of England contain a comparatively large bryozoan fauna which has received but little study. Of this series the Buildwas beds seem to hold a fauna most similar to that of the Rochester shale, and a careful comparison of the two will probably bring out the fact that they are closely related.

BIBLIOGRAPHY.

The following review contains references to the literature bearing on the bryozoa found in these shales and a brief outline of the work done in each case:

GRABAU, A. W. Guide to the geology and paleontology of Niagara Falls and vicinity. Bull. N. Y. State Museum No. 45, 1901, pp. 161–176. Gives figures and the distinguishing characters of some of the bryozoa described by Hall from the Rochester shale at Lockport, and states occurrence at Niagara Falls.

GRABAU, A. W. Bull. Buffalo Soc. Nat. Sci., VII, No. 1, 1901. Reprint of the above paper.

HALL, JAMES. Natural History of New York, Geology, IV, 1843, p. 116, figs. 2, 3. A good figure of the reverse of *Pseudohornera diffusa* is given as a "coral resembling Isis."

HALL, JAMES. Natural History of New York, Paleontology, II, 1852. Describes as corals the following new genera and species of bryozoa, all from Lockport, N. Y., a few species, however, being also recorded from Rochester and other localities in western New York: *Callopora* n. gen., *C. elegantula* n. sp., *C. florida* n. sp., *C. laminata* n. sp , *C. aspera* n. sp., *C. nummiformis* n. sp., *Trematopora* n. gen., *T. tuberculosa* n. sp., *T. coalescens* n. sp. *T. punctata* n. sp., *T. ostiolata* n. sp., *T. solida* n. sp., *T. striata* n. sp., *T. granulifera* n. sp.. *T. aspera* n. sp., *T. spinulosa* n. sp., *T. sparsa* n. sp , *Stictopora punctipora* n. sp., *Diamesopora dichotoma* n. gen. et sp. (genus not characterized), *Clathropora* n. gen., *C. alcicornis* n. sp., *C. frondosa* n. sp., *Retepora diffusa* n. sp., *R. asperato-striata* n. sp., *Hornera* (?) *dichotoma* n. sp., *Fenestella elegans* n. sp., *F. tenuiceps* n. sp., *F. cribrosa* n. sp. (from lower part of Niagara limestone), *Polypora incepta* n. sp., *Ceramopora* n. gen., *C. imbricata* n. sp., *C. incrustans* n. sp., *C. foliacea* n. sp., *Rhinopora tuberculosa* n. sp *Lichenalia* n. gen., *L. concentrica* n. sp., *Sagenella* n. gen., *S. membranacea* n. sp.

HALL, JAMES. Natural History of New York, Paleontology, VI, 1887, pl. 61. Figures by mistake a species from the Rochester shale and names it *Stictopora scitula*.

NICHOLSON, H. A., and HINDE, G. J. Canadian Journal, new ser., XIV, 1874. They record the occurrence of *Clathropora frondosa*, *C. intermedia*, and *Retepora asperato-striata* in the Niagara limestone (Rochester shale) at Thorold Ontario, and of *Trematopora ostiolata* and *Fenestella tenuiceps* at Niagara River. They also give descriptions and comparisons of *Clathropora frondosa* and *C. intermedia*, the latter being a new species. Figures of *Clathropora intermedia* and *Trematopora ostiolata* are given.

NICHOLSON, H. A. Paleontology of the Province of Ontario, 1875, pp. 59, 60. So far as the bryozoa of the Rochester shale are concerned, this is a reproduction of the preceding work.

NICHOLSON, H. A. Geological Survey of Ohio, Paleontology, II, 1875, p. 264, pl. 25, figs. 11, 11a. Describes and figures *Fenestella nervata* n. sp. from the Niagara at Cedarville, Ohio. This species has since been recognized in the Rochester shale in New York and Ontario.

NICKLES, JOHN M., and BASSLER, R. S. Synopsis of American fossil bryozoa. Bull. U. S. Geol. Survey No. 173, 1900. They record the literature and synonomy of Rochester shale as well as other American fossil bryozoa.

RINGUEBERG, E. N. S. New genera and species of fossils from the Niagara shales. Bull. Buffalo Soc. Nat. Sci., V. 1886. Describes as new species from Lockport, N. Y., *Ceramopora orbiculata*, *Rhinopora curvata*, *Stomatopora recta*, *S. parva*, and *Chætetes expansus*.

ROEMER, FERD. Lethæa Geognostica, I, Lethæa Palæozoica, Atlas, 1876, pl. 12, figs. 2a, 2b, 4a–4c. Reproduces some of Hall's figures of *Retepora diffusa* Hall, and in the explanation of the plate applies the new name *Pseudohornera diffusa*. Figures, as a new species from the island of Gotland, *Ptilodictya fenestrata*, a form very much like *Clathropora frondosa* Hall.

ULRICH, E. O. American Paleozoic bryozoa. Jour. Cincinnati Soc. Nat. Hist, V–VII, 1882–1884. In discussing *Homotrypa* some of the characters of *Trematopora tuberculosa* Hall are stated in Vol. V, p. 241. A full description of *Callopora elegantula* Hall, is given on page 250. In Vol. VI, p. 257, he discusses Hall's genus *Trematopora* and gives an amended definition. Hall's species are distributed as follows: *Trematopora coalescens=Trematopora*, *T. solida=Trematopora?*, and *T. ostiolata=Chilotrypa*. On page 259 he describes *Trematopora tuberculosa* Hall. In Vol. VII, p. 39, in discussing *Coscinium* Keyserling, he remarks on Hall's genus *Clathropora* and the type species *C. frondosa*. Pages 43–44 give some of the characters of *Lichenalia* and the type species *L. concentrica*, of which he figures a tangential section in Pl. III, fig. 5. On page 49 he refers to his new genus *Chilotrypa* Hall's *Trematopora ostiolata*.

ULRICH, E. O. Paleozoic bryozoa. Geol. Survey Illinois, VIII, 1890. On page 368 the genus *Diplodema* is established and *Trematopora sparsa* Hall is made one of the types. The new genus *Stictotrypa* is founded (p. 393), with *Stictopora similis* Hall as the genotype, and on page 394, fig. 13, a vertical section of *S. similis* Hall and tangential and vertical sections of *S. punctipora* Hall are given. On page 399 *Drymotrypa* n. gen. is described, *Retopora diffusa* Hall being made the type. Hall's *Thamniscus niagarensis* is referred here. On page 425, in discussing the genus *Lioclema*, the following of Hall's species are referred here: *Callopora aspera*, *C. florida*, and *C. laminata*. On page 463 a full description of *Ceramopora imbricata*, accompanied by figures of the internal structure, is given. The genus *Diamesopora* is discussed on page 467. On page 607, when discussing *Thamniscus*, *Hornera dichotoma* Hall is referred here, while *Thamniscus niagarensis* Hall belongs to *Drymotrypa*.

ULRICH, E. O., and BASSLER, R. S. A revision of the Paleozoic bryozoa. Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904. They describe and figure *Rhopalonaria attenuata* n. sp., *Vinella radiciformis* (Vine), *V.* (?) *multiradiata* n. sp., and *Ascodictyon siluriense* Vine, from the Rochester shale.

VINE, G. R. Silurian uniserial Stomatoporæ and Ascodictyon. Quart. Geol. Jour. Soc. London, XXXVII, 1881. Figures and describes on page 615, *Stomatopora dissimilis* n. sp. from the Buildwas beds, Wenlock shales, Shropshire, England.

VINE, G. R. Notes on the polyzoa of the Wenlock shales, Wenlock limestone and shales over Wenlock limestone. Quart. Jour. Geol. Soc. London, XXXVIII, 1882. Describes among other Silurian species the following, which have been recognized in the Rochester shale: *Stomatopora dissimilis*, *S. dissimilis* var. *elongata*, *Ascodictyon stellatum* var. *siluriense*, *Ascodictyon radiciforme*, and *Diastopora consimilis*.

DESCRIPTIONS OF GENERA AND SPECIES.

Class BRYOZOA Ehrenberg.

Order CTENOSTOMATA Busk.

The zoarium in this relatively small order is horny or membranaceous, and consists of tubular stolons, from the internodes of which the zoœcia are developed. The zoœcia are usually isolated and have a terminal orifice which in the living state is closed by an operculum composed of setæ.

When compared with the other orders of bryozoa, species of Ctenostomata are not common in the Rochester shale, five representing four genera having thus far been found This, however, is not unusual, as the order is poorly represented in all the geologic formations. The infrequency of fossil Ctenostomata may be accounted for by the prevailing character of their zoaria, the zoarium in the majority of the living types of this order being membranaceous, and hence incapable of preservation in the fossil state.

One of the Rochester shale species, *Rhopalonaria attenuata*, is represented by numerous specimens; another, *Vinella radiciformis*, is uncommon; while the remaining three, *Vinella multiradiata*, *Ascodictyon siluriense*, and *Allonema waldronense* are comparatively rare. Continued searching will probably reveal the presence of species belonging to another ctenostomatous genus, namely *Heteronema*, since representatives of this genus are known in other Silurian strata.

Mr. Ulrich and the writer have recently made the fossil Ctenostomata the subject of a small monograph [a], and the following descriptions are based mainly on this work. Since this publication, no new species have been found in the Rochester shale, although several new forms have come to light in other horizons.

Family RHOPALONARIIDÆ Nicklas and Bassler.

Genus RHOPALONARIA Ulrich.

All the species of this genus closely resemble each other, since, as a rule, nothing remains but the impressions of the stolons—clay-filled or empty excavations in the body incrusted. However, experience has shown that the variation in the dimensions of these more or less accurate impressions serves as well in discriminating the species as the zoaria themselves.

Rhopalonaria is distinguished from all other genera of the Ctenostomata by the fusiform internodes or cells, by their pinnate arrangement, and by the fact that they excavate their host.

RHOPALONARIA ATTENUATA Ulrich and Bassler.

Pl. IV, figs. 4, 5.

Rhopalonaria attenuata Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, p. 268, pl. 66, figs. 4, 5.

In all the specimens at hand this species is represented by a series of excavations upon the surface of the object it incrusted, crinoid columns, cystid plates, brachiopods, and bryozoans being used indiscriminately. These impressions show that the zoarium consisted either of slender stolons constricted at rather regular intervals or of segments slightly fusiform in

[a] Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, pp. 256-294.

outline. From a central stolon or series of segments, lateral branches are given off at approximately right angles, and in the same manner these divide again until the result is a network of anastomosing branches arranged pinnately. Length of segments somewhat variable, 3 to 3.5 in 2 mm. Orifice not observed because of the preservation, but probably situated in the swollen end of the segments.

The differences between this species and *R. venosa* Ulrich [a] from the Richmond group are slight, the length and arrangement of the internodes and stolons being practically the same in each. *R. attenuata*, however, may be distinguished by the extreme tenuity of the internodes and stolons, and by the comparative rigidity of their arrangement. The zoœcial and zoarial features of the two, if preserved, would probably show more differences, but as the excavations alone have been found, slight variations must serve in discriminating species.

Occurrence.—The figured types were found in the Rochester shale at Lockport, N. Y., where specimens are not uncommon. Examples have also been found in the same formation at Rochester and Lewiston, N. Y., in the Niagara Gorge, and at Grimsby and Thorold, Ontario. The Clinton limestone at Mifflintown, Juniata County, Pa., and the Waldron shale at Waldron, Ind., and at Newsom, Tenn., furnish specimens which can not be separated from the typical form.

Catalogue numbers, 43116, 43117, 35733, 35477, U. S. National Museum.

Family VINELLIDÆ Ulrich and Bassler.

Genus VINELLA Ulrich.

Zoarium parasitic, consisting of very slender, tubular threads or stolons, arranged more or less distinctly in a radial manner. Surface of threads with a single row of small pores, which may be wanting locally and may vary considerably in the degree of their separation. Zoœcia unknown, probably deciduous.

VINELLA RADICIFORMIS (Vine).

Pl. IV, figs. 2, 3.

Ascodictyon radians Vine (part), Quart. Jour. Geol. Soc. London (provisional placement), XXXVII, 1881, p. 619.

Ascodictyon radiciforme Vine, ibid., XXXVIII, 1822, p. 53, figs. 1, 3.

Ascodictyon radiciforme Vine, Ann. and Mag. Nat. Hist. (5), XIV, 1884, p. 83, figs. 1–5.

Ascodictyon radiciforme Vine, Proc. Yorkshire Geol. and Polytech. Soc., IX, 1887, pp. 183–4, pl. 12, fig. 5.

Ascodictyon radiciforme Vine, ibid., XII, 1892, p. 87.

Vinella radiciformis Ulrich, Geol. and Nat. Hist. Survey Minnesota, Final Rept., III, pt. 1, 1893, p. 113.

Vinella radiciformis Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, p. 275. pl. 68, fig. 7.

This species, originally described from the Wenlock shales, has been noted at a number of American localities. Its delicate zoaria are generally found incrusting smooth-shelled brachiopods, crinoid columns, or the epithecated side of bryozoa, such as explanate species of *Fistulipora* or *Lioclema*. The rather widely separated nuclei and the extreme tenuity of the radiating threads are especially characteristic. Near the centers themselves the radii are slightly swollen, but their average thickness elsewhere lies between 0.03 and 0.04 mm. Sometimes the threads seem to bifurcate or to wander about without much order, and often the nuclei are difficult to distinguish from the points where the threads merely cross.

Occurrence.—Buildwas beds of the Wenlock shales, Shropshire, England; Rochester shales, Rochester and Lockport, N. Y.; Grimsby, Ontario; Waldron shale, Waldron, Ind; Clinton formation, Sevenmile Creek, near Eaton, Ohio.

Catalogue numbers, 35476, 43145, 43146, U. S. National Museum.

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[a] Ulrich, Jour. Cincinnati Soc. Nat. Hist., II, 1879, p. 26, pl. 7, figs. 24, 24a.

VINELLA? MULTIRADIATA Ulrich and Bassler.

Pl. IV, fig. 1.

Vinella? multiradiata Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, p. 276, pl. 68, fig. 8.

But two specimens of this interesting and peculiar organism have been found, and, as no additional facts have been observed, the remarks by Ulrich and the writer in describing the species are quoted below.

Original description.—The specimen on which this peculiar species is founded incrusts a crinoid column about three-fourths of an inch in length, about two-thirds covered with the supposed *Vinella*. At intervals varying from little more than 0.5 mm. to about 2 mm. the surface of the incrusting sheet presents subcircular, cup-shaped depressions, 0.12 mm. to 0.2 mm. in diameter, inclosed by a low rim from which 14 to 20 closely arranged threads proceed in all directions. The radii are commonly disposed in sets of three to five, those emanating from neighboring centers overlapping and interweaving in the interspaces. The sheet seems to consist in most parts of at least two superposed layers. Minute details of structure not preserved.

At first sight, under a low power of magnification, the specimen recalled the attached basal disks of articulating bryozoa, like *Arthropora* and *Escharopora*, but it soon became evident that the resemblance was deceptive and extended only to the common possession of cup-shaped depressions and lines radiating from them. Under a higher power the radii proved to be simple threads and not radially arranged walls separating rows of elongated zoœcial apertures, which is the structure of the attached disks of the articulating bryozoa referred to. Of course the much smaller size of the *Vinella* was apparent from the beginning of our investigations. Though now thoroughly satisfied that we are not dealing with bases of zoaria, we think it quite possible that they may prove to be the bases of isolated zoœcia. Whatever the future may prove it to be, it impresses us as a very interesting organism, and it is the hope that other collectors may succeed in finding more and better specimens that has induced us to describe it.

Occurrence.—Rochester shale, Lockport, N. Y.

Catalogue number, 43144, U. S. National Museum.

Genus ALLONEMA Ulrich and Bassler.

Original description.—Fossil zoaria of which only the creeping base is known. This attaches itself to foreign bodies and consists of strings of sausage-like, bulbous, fusiform or pear-shaped internodes or vesicles varying greatly in size in different species. Surface of internodes minutely punctate, while a number in each colony exhibit a larger pore-like depression, usually near one end of the vesicle or internode that is regarded as marking the point where erect zoœcia were attached.[a]

ALLONEMA WALDRONENSE Ulrich and Bassler.

Pl. IV, fig. 9.

Allonema waldronense Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, p. 283, pl. 67, fig. 5.

A single small example of this rather uncommon species was found incrusting the epitheca of a fistuliporoid in the Rochester shale at Middleport, N. Y. This specimen agrees so closely with the type that for purposes of identification the original description is repeated below.

Original description.—Colonies small, consisting of an irregular, winding series of comparatively few and rather large, inflated internodes. The series branches occasionally, and a few of the internodes appear to be quite isolated. The internodes vary greatly in form, some being globular or elliptical, others pyriform, and a few of the largest bilobate. The last probably consist of two partially confluent vesicles. With all this variation, the internodes still remain within reasonable distance of the average size that we consider characteristic of the species. The average length may be placed at about 0.5 mm., the width at 0.3 mm.

Occurrence.—Waldron shales of the Niagaran group, Waldron, Ind.; Rochester shale, Middleport, N. Y.

Catalogue number, 43128, U. S. National Museum.

[a] Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLV, 1904, p. 279.

Family ASCODICTYONIDÆ Ulrich.

Genus ASCODICTYON Nicholson and Etheridge, jr.

Zoarium parasitic, consisting of ovate or pyriform vesicles, arranged in radial clusters or isolated, and connected with each other by very delicate, hollow threads. Walls of vesicles perforated by closely arranged, minute pores. Zoœcia unknown.

ASCODICTYON SILURIENSE Vine.

Pl. IV, figs. 6–8.

Ascodictyon stellatum Vine, Quart. Jour. Geol. Soc. London, XXXVII, 1881, p. 618.
Ascodictyon stellatum var. *siluriense* Vine, ibid., XXXVIII, 1882, p. 52, figs. 1, 2.
Ascodictyon stellatum var. *siluriense* Vine, Ann. and Mag. Nat. Hist. (5), XIV, 1884, p. 81, fig. 7.
Ascodictyon stellatum var. *siluriense* Vine, Proc. Yorkshire Geol. and Polytech. Soc., IX, 1887, p. 184, pl. 12, fig. 6.
Ascodictyon siluriense Vine, ibid., XII, 1892, p. 88, pl. 2, fig. 1.
Ascodictyon siluriense Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. Issue), XLV, 1904, p. 208, pl. 68, figs. 11, 12.

Description (Ulrich and Bassler).—Vesicles pyriform, the small end more or less drawn out, 0.1 mm to 0.2 mm. in diameter, and 0.3 mm. to 0.5 mm. in length, arranged in clusters of four to eight, with clusters of four or five occurring oftener than six to eight. Connecting threads about 0.03 mm. in thickness, comparatively straight, with clusters of vesicles occurring at intervals of 2.5 mm. or more.

Compared with *A. stellatum*, this species is distinguished by its usually fewer and less closely arranged vesicles in each cluster, by the greater average length and more pyriform shape of the vesicles, and by the comparative rigidity of the connecting threads.

Several well-preserved examples of this cosmopolitan Silurian species have been found in the Rochester shale at Lockport. The pyriform radially arranged vesicles and the delicate connecting threads form a zoarium so different from all associated bryozoa that comparison is unnecessary.

Occurrence.—Vine's types were found in the Wenlock shale, Buildwas beds, Shropshire, England. In America the species occurs in the Rochester shale at Lockport, N. Y., and in the Waldron shale at Waldron, Ind., and Newsom, Tenn.

Catalogue numbers, 43135, 43138, U. S. National Museum.

Order CYCLOSTOMATA Busk.

The simple tubular zoœcia with thin, minutely porous walls, the absence of marsupia and appendicular organs and the presence of oœcia characterize this order. The Cyclostomata are fairly well represented in this formation, the majority of the species belonging to the *Ceramoporidæ* and *Fistuliporidæ*, two families which have only recently been referred to the order with certainty.

Family DIASTOPORIDÆ Busk (emend. Ulrich).

Genus STOMATOPORA Bronn.

Zoarium adnate, branching dichotomously; zoœcia subtubular or subpyriform, arranged in a single linear series; aperture subterminal.

STOMATOPORA ELONGATA (Vine).

Pl. IV, figs. 10–14.

Stomatopora dissimilis var. *elongata* Vine, Quart. Jour. Geol. Soc. London, XXXVIII, 1882, p. 50.
Stomatopora elongata Vine, Ann. and Mag. Nat. Hist. (5), XIV, 1884, p. 85, fig. IV, 2.
Stomatopora parva Ringueberg, Bull. Buffalo Soc. Nat. Hist., V, 1886, p. 20, pl. 2, fig. 16.

Original description (Vine).—*Stomatopora dissimilis* Vine var. a. *elongata*. Zoarium very irregular, clustering. Zoœcia elongated, with, at times, long stoloniferous processes which intermingle with the cells. When colonial growth is distinct, arrangement of cells is linear and uniserial. Measured under favorable circumstances, about three cells occupy the space of one line.

Locality.—Buildwas beds (Wenlock shales), England.

The collection of Mr. John M. Nickles contains an example of this species from the original Wenlock shales material studied by Mr. Vine. Fig. 10, Pl. IV, represents several of the zoœcia of this specimen enlarged, and a comparison of this figure with those of the American form shows that there can be little doubt of the specific identity of the two. This English specimen is labeled *Stomatopora elongata* in Mr. Vine's handwriting, so that there is no question of its authenticity. The long stoloniferous processes which Mr. Vine mentions as intermingling with the cells are the stolons of ctenostomatous bryozoa such as *Vinella* or *Ascodictyon* and have no connection at all with the *Stomatopora*. Such widely diverse incrusting species are often found with their zoaria intermingled and but little care is usually required to determine that one is merely growing over the other. The following description brings out the characters as observed by the writer:

Zoarium incrusting foreign objects, the smooth epitheca of corals or bryozoa being most favored in the American examples. Zoœcia uniserial, branching at irregular intervals, slender, fusiform, increasing slowly in size from a diameter of 0.03 to 0.04 mm. at the proximal end to one of 0.15 to 0.18 mm. at the distal or anterior end, which, although normally rounded, is sometimes slightly drawn out. An average zoœcium is 0.60 mm. in length; when arranged in a straight line, seven zoœcia may be counted in the space of 4 mm. Aperture small, rounded, subterminal, with a slightly elevated border and less than half the greatest width of the zoœcium in diameter. Surface of the zoœcia smooth, probably finely porous.

Compared with other uniserial forms of *Stomatopora*, *S. elongata* resembles *S. delicatula* James, which ranges through the Mohawkian and Cincinnatian groups, but the latter species has slightly longer and more slender zoœcia. In all probability *S. elongata* is the Silurian representative of the Ordovician *S. delicatula*. The very much larger and relatively shorter, transversely wrinkled zoœcia of the associated *Stomatopora dissimilis* are so different that comparisons are scarcely necessary.

The American form here identified as *Stomatopora dissimilis* is probably the same as *Stomatopora parva* Ringueberg, but the description and figures of the latter are so poor that without an examination of the type specimen the synonymy can not be determined with absolute certainty. In spite of this uncertainty, the writer has ventured to place Ringueberg's species as a synonym on the strength of his original description, which, for the sake of comparison, is quoted below:

> Adnate, minute, irregularly branching. Cells uniserial subcylindrical, not inflated, somewhat variable in length, some being a third shorter than the average. Calice slightly elevated. This species is about one-third as large as *S. recta* and is readily recognized by its minute size and straight cells. (From the Niagara shales at Lockport N. Y.)

Occurrence.—Buildwas beds, Wenlock shales, Shropshire, England; Clinton formation, Sevenmile Creek, near Eaton, Ohio; Rochester shale, Rochester and Lockport, N. Y., Waldron shale, Newsom, Tenn

Catalogue number, 35475, U. S. National Museum.

STOMATOPORA DISSIMILIS Vine.

Pl. IV, figs. 15-19.

Stomatopora dissimilis Vine, Quart. Jour. Geol. Soc. London XXXVII, 1881, pp. 615, 616, figs. 1-8; XXXVIII, 1882, p. 50.

Stomatopora recta Ringueberg, Bull. Buffalo Soc. Nat. Hist., V, 1886 p. 20 pl. 2, figs. 15, 15a.

Aulopora sp. Hall Nat. Hist. New York, Pal. II, 1852, pl. 50, figs 27, 29.

Original description.—Zoarium adnate, branching generally attached to stems of Crinoidea, very rarely to broken shells; branches linear, sometimes wavy and anastomosing. Zoœcia invariably uniserial, and, in the best preserved, very finely ribbed transversely; the distal extremity slightly raised; orifice circular or subcircular. Oœcial cells rather ventricose and strongly ribbed (?). Each normal zoœcium about half a line; average about 6 to 3½ lines.

A series of specimens from the Silurian rocks of various localities in Europe and America shows that the Wenlock shales species described by Vine as *Stomatopora dissimilis* has as

wide a distribution as the accompanying Cyclostomata, *Stomatopora elongata* Vine, and *Berenicea consimilis* (Lonsdale). As indicated in the above synonymy, the American form was figured by Hall in 1852 without a specific designation, and later was figured and described by Ringueberg as *Stomatopora recta*.

The zoarium of *S. dissimilis* is parasitic, other bryozoa, brachiopods, and crinoid columns or plates being usually selected; uniserial, with lateral series branching usually irregularly but sometimes very regularly and at right angles to the main series. Zoœcia subcylindrical or club shaped, about 0.10 mm. in diameter at the proximal end and increasing to 0.35 mm. at the rounded distal portion; an average zoœcium is 1.15 mm. in length with 5 to 6 in 5 mm. Apertures large, subterminal, bounded by a raised rim-like border. Zoœcia marked transversely by fine wrinkles or striations.

The large zoœcia with their transverse striations or wrinkles particularly characterize *S. dissimilis* and serve to distinguish it from all other Paleozoic species of the genus.

Occurrence.—Vine's types are from the Buildwas beds of the Wenlock shales, Shropshire, England. The species occurs also in the Silurian beds on the island of Gotland; in the Rochester shale at Rochester, Lockport, Middleport, Niagara Falls, and other localities in western New York; in the same shale at Grimsby, Ontario; and in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35472, 35473, 44112, 44113, U. S. National Museum.

Genus BERENICEA Lamouroux.

The adnate zoarium of thin, discoid, flabellate or irregular crusts with tubular zoœcia arranged in irregularly alternating lines distinguishes this genus from other members of the *Diastoporidæ*.

BERENICEA CONSIMILIS (Lonsdale).

Pl. V, figs. 1–5.

Aulopora consimilis Lonsdale, in Murchison's Sil. System, pt. 2, 1839, p. 675, pl. 15.
Diastopora (Aulopora) consimilis Vine, British Assoc. Rept., 1881.
Diastopora consimilis Vine, Quart. Jour. Geol. Soc. London, XXXVIII, 1882, p. 58.
Diastoporella consimilis Vine, British Assoc. Rept., Foss. Polyzoa, IV, 1883.
Diastoporella consimilis Vine, Proc. Yorkshire Geol. and Polytech. Soc., IX, 1887, p. 190, pl. 12, figs. 18–20.
——— ——— Hall, Nat. Hist. New York, Pal. II, 1852, p. 173, pl. 40E, figs. 8a, b.
Sagenella elegans Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 7, figs. 12, 13; ibid. (Mus. ed.), 1879, p. 118 pl. 7, figs. 12, 13.
Sagenella elegans Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882, p. 242, pl. 6, figs. 12, 13.
Sagenella elegans Simpson, Fourteenth Ann. Rept. State Geol. New York for the year 1894, 1897, pl. 20, fig. 4.
Berenicea elegans Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 181.
Sagenella membranacea Hall, Nat. Hist. New York, Pal. II, 1852, p. 172, pl. 40E, fig. 6a, b.
Berenicea membranacea Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 181.

A study of many specimens from various Silurian localities in Europe and America has shown that the species first described by Lonsdale as *Aulopora consimilis* is a cosmopolitan form ranging throughout several formations but eminently characteristic of the Silurian rocks as a whole. Lonsdale's description and figures are complete enough for the determination of the form, but the species is more accurately defined in the later work of Vine. A comparison of the types of *Sagenella elegans* and *S. membranacea* with specimens from England and Gotland indicates that all represent the same species. *Sagenella membranacea* is founded upon a worn example from the Rochester shale, while the type of *S. elegans* from the Waldron beds is a normal specimen growing upon a pelecypod.

Lonsdale's original description is as follows:

Aulopora consimilis sp. n., Lons. pl. 15, f. 7, magnified twice. A. incrusting, tubes round, close together, radiated, bifurcated; openings circular, raised; margin thick. This fossil is singularly like *Aulopora compressa* of Goldfuss (Petref., p. 84, Taf. XXXVIII, f. 17), found in the Oolitic series of Germany.

The essential characters, as viewed by the writer, are given in the following description:

Zoarium incrusting foreign bodies, the smooth shells of brachiopods or crinoid plates being usually favored. Growth commencing at a point from which the zoœcia radiate. Zoœcia contiguous, cylindrical, about 1 mm. in length and 0.22 mm. wide. Aperture circular, slightly raised, about 0.20 mm. in diameter. Zoœcia marked by delicate transverse annular striations.

The elongate, sharply defined, transversely lined zoœcia form the important specific character and distinguish this beautiful species from other Paleozoic forms of the genus.

Occurrence.—Wenlock limestone, Dudley, England (Lonsdale); Buildwas beds, Wenlock shales, Shropshire, England; Silurian, island of Gotland; Rochester shale, Rochester, Lockport, and other localities in western New York, and Grimsby, Ontario; Osgood beds, Osgood, Ind.; Waldron beds, Waldron, Ind., and Newsom, Tenn.

Catalogue numbers, 35565, 35474, 44114, 44115, U. S. National Museum.

Family ENTALOPHORIDÆ Reuss.

Genus DIPLOCLEMA Ulrich.

Zoarium ramose, with tubular zoœcia diverging on all sides from a wavy mesial lamina; apertures circular, prominent.

DIPLOCLEMA SPARSUM (Hall).

Pl. V, figs. 6, 7; Pl. XXIII, figs. 4-6.

Trematopora sparsa Hall, Nat. Hist. New York, Pal. II, 1852, p. 155, pl. 40A, figs. 12 a-d.
Diploclema sparsa Ulrich, Geol. Survey Illinois, VIII, 1890, p. 368, pl. 53, fig. 10.
Diploclema sparsa Grabau, Bull. New York State Mus. Nat. Hist., No. 45, 1901, p. 162, fig. 57.

The zoarium of this species is composed of small, subcylindrical ramulets, ovate in cross sections, about 0.5 mm. in width, 0.3 to 0.4 mm. in thickness, and dividing dichotomously at intervals of 10 mm. or more. The zoœcia are thin walled, long, tubular, opening upon the surface with slightly protruding circular apertures, which, when well preserved, are surrounded by a peristome, 0.15 to 0.18 mm. in diameter; four zoœcia in 2 mm. measuring longitudinally; a branch is formed of five or six linear series, adjacent series alternating. Interapertural space smooth or very faintly granulose.

The widely separated rounded apertures and the small branches celluliferous on all sides readily distinguish this neat little species. Small fragments of *Thamniscus dichotomus* Hall might be confused, but the more closely distributed apertures and branches, celluliferous on one side only, distinguish that form superficially, the internal structure of the two being quite different.

Diploclema sparsum has been considered by both Vine and Ulrich to be closely related to *Spiropora regularis* Vine from the Wenlock of England, but a critical comparison of the American species with specimens of the latter received from Mr. Vine shows the two forms to be specifically quite distinct. *Diploclema* (*Spiropora*) *regularis* forms more robust zoaria, the branches averaging almost 1 mm. in diameter, while measuring longitudinally two zoœcia are found in 2 mm. The branches of *Diploclema sparsum*, as mentioned above, are 0.5 mm. in diameter and have four zoœcia in 2 mm.

Occurrence.—Rochester shale, Lockport, Rochester, Niagara Falls, and other localities in New York; Grimsby and Hamilton, Ontario.

Catalogue numbers, 35734, 44071, U. S. National Museum.

DIPLOCLEMA SPARSUM var. ARGUTUM n. var.

Pl. V, figs. 8, 9.

This subordinate name is proposed for the reception of a number of specimens which differ from *Diploclema sparsum* in the following respects: First, the zoarium is more robust, cylindrical, and bears four or five ranges of zoœcia upon each side, while the typical form

of the species is of slender ramulets, showing only two or three rows of zoœcia. Second, specimens of the variety very commonly exhibit a distinct pore in front of each zoœcial aperture, while in the species itself this pore is rarely seen.

Vine probably had this variety in mind when he identified his *Spiropora regularis* [a] as occurring at Lockport, N. Y. However, *D. sparsum* and variety *argutum* differ decidedly from *Spiropora regularis* in that the latter has considerably larger zoœcia.

Occurrence.—Not uncommon at Lockport, N. Y.

Catalogue number, 35557, U. S. National Museum.

Genus MITOCLEMA Ulrich.

Mitoclema Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, 1882, p. 150.
Compare *Clonopora* Hall, Nat. Hist. New York, Pal. VI, 1886, p. 25, and *Entalophora* Lamouroux Exp. meth. des genres de pol., 1821, p. 81.

Ramose Cyclostomata composed of long tubular zoœcia diverging from an imaginary axis in all directions to the surface, where they bend outward, and often become free and much produced. Apertures circular, usually arranged in regular transverse or subspiral series.

As to the advisability of referring the following new species to the Ordovician genus *Mitoclema* or to the very similar *Clonopora*, founded upon Devonian forms, the writer is still in doubt. Both of these genera may eventually prove to be synonyms of the recent genus *Entalophora*. Undoubted species of *Stomatopora* and *Berenicea* are found in most of the formations from Ordovician to recent times, and it is not at all unlikely that *Entalophora* will also prove to be one of these long-enduring simple cyclostomatous generic types.

MITOCLEMA SARLEI n. sp.

Pl. V, figs. 10-12.

Zoarium of very small, slender, ramose, cylindrical branches 0.35 to 0.45 mm. in diameter. Zoœcia long, tubular, with circular apertures about 0.1 mm. in diameter projecting upward and outward from the body of the stem. Measuring longitudinally, there are about three zoœcia in 2 mm. The space between the zoœcial apertures is generally smooth, but sometimes exhibits faint transverse wrinkles.

All of the specimens of this species so far observed are attached to slabs, but these indicate that each branchlet bears four longitudinal rows of zoœcia whose apertures are so placed that a somewhat regular ascending spiral series is the result. In the number of zoœcia, *M. sarlei* is different from all of the described species of the genus, no other form having so few rows of apertures.

This neat species is named in honor of Mr. Clifton J. Sarle, of Rochester, N. Y., who kindly collected a considerable number of bryozoa at that place for the writer.

Occurrence.—Common on the thin slabs of limestone in the Rochester shale at Rochester, N. Y.

Catalogue number, 35460, U. S. National Museum.

Family CERAMOPORIDÆ Ulrich.

Genus CERAMOPORA Hall.

In 1890 Ulrich [b] restricted the genus *Ceramopora* to the type species, *C. imbricata*, making the peculiar, spongy, basal tissue in connection with the indefinite wall structure, large openings in the walls, and absence of diaphragms, the characteristic features. Since that time other undoubted species of *Ceramopora* have been discovered which show that the more important characters of the genus are the indefinite wall structure of both zoœcia and mesopores and the large openings in the walls allowing neighboring tubes to communicate

[a] Quart. Jour. Geol. Soc. London, XXVIII, 1882, p. 56, figs. 4-6.
[b] Geol. Survey Illinois, VIII, 1890, p. 493.

with each other. The growth may be free, discoid, lamellate, massive, or incrusting, the spongy basal layer may be absent, and the diaphragm may or may not occur.

The various species of *Ceramopora* may be distinguished by external features that are more readily perceived by a study of actual examples than by description. This peculiar aspect of the surface seems to be the result of the open mesopores, together with the irregularity of both zoœcia and mesopores, and the prominent lunaria.

CERAMOPORA IMBRICATA Hall.

Pl. VI, figs. 1-10.

Ceramopora imbricata Hall, Nat. Hist. New York, Pal. II, 1852, p. 169, pl. 40E, figs. 1a-l.
Ceramopora imbricata Ulrich, Geol. Survey Illinois, VIII, 1890, p. 463, pl. 39, figs. 1-1b.
Ceramopora imbricata Grabau, Bull. New York State Mus., No. 45, 1901, p. 163, fig. 58.

Ulrich (op. cit.), has brought out the salient features of this species in the following description:

Zoarium free, discoidal, plano-convex, under side sometimes slightly concave, from 5 to 15 mm. in diameter; thickness at center seldom exceeding 4 mm., usually only about 2 or 3 mm. No epitheca on the lower side. Lower or basal portion of zoarium composed of a cellular or spongy tissue, from which the zoœcia grow out more or less obliquely. At the depressed center of the zoarium the zoœcia are nearly direct, but toward the margin they gradually become more and more oblique. Zoœcia compressed tubular, being long oval in transverse section. Apertures imbricating, arranged in multiplying radial series, all facing away from the center, triangular or oval in outline, 0.5 to 0.7 mm. in their long diameter. Intercellular space occupied by irregularly flexuous rows of mesopores, variously shaped, short. Zoœcial tubes and mesopores communicate rather freely by means of perforations in the walls. Besides, the walls have that granular structure which is supposed to indicate originally minutely porous condition. Lunarium small, yet well marked. No diaphragms developed.

To the above may be added that growth in this species commences parasitically on small foreign objects, crinoid stems being usually selected. As new tubes are added, the free disk-shaped zoarium results by growth beyond the object originally incrusted. The latter in some specimens is still preserved but more frequently is represented only by the cicatrix of attachment. Measuring along one of the rows radiating from a macula, three zoœcia are usually found in a distance of 2 mm. A young or even average specimen is made up of a central macula from which the zoœcia radiate toward the growing edge, but larger examples exhibit several maculæ.

The discoid growth, spongy basal layer, and the conspicuous maculæ with the radiating, oblique, imbricated zoœcia are characters by which this species can readily be distinguished not only from all associated bryozoa but also from other species of *Ceramopora*. *Mesotrypa nummiformis* has a similar discoid method of growth but the much smaller zoœcia, absence of a lunarium and the epithecated under surface are external characters which will distinguish it at once.

Occurrence.—Not uncommon in the Rochester shale at Rochester, Lewiston, and Lockport, N. Y., and in the same formation at Thorold and Grimsby, Ontario. Rather abundant in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35464, 35465, 35466, 43280, U. S. National Museum.

CERAMOPORA NIAGARENSIS n. sp.

Pl. VI. figs. 11-13.

Zoarium explanate, at first attached to foreign bodies, then becoming free and provided with an epitheca; by the superposition of several layers, rounded or irregular lumps 2 to 4 cm. in diameter may result. Thickness of the individual layers of a zoarium varying from 1 to 2 mm. Celluliferous surface rough on account of the prominent lunaria and exhibiting well-marked maculæ composed of open mesopores. Zoœcial apertures nearly direct, ovate, three in 2 mm., rather regularly arranged about the maculæ. Lunarium strongly elevated and well developed, occupying the posterior half of the zoœcial aperture. Mesopores, as usual in the genus, open at the surface and variable in size, shape, and number, but commonly about two to a zoœcium.

Vertical sections show that the walls of the tubes are at first thin but thicken in the mature region where the characteristic indefinite structure and the pore-like openings are well exhibited. Diaphragms wanting. In tangential sections the large, well-defined lunarium projecting in the zoœcial cavity is the special feature, while the ovate zoœcia, irregular mesopores, and indefinite wall structure are also well brought out.

With the exception of *Ceramopora imbricata* and *C. labecula*, all of the Niagaran species described by Hall under *Ceramopora* appear to be fistuliporoids. The free zoarium of *C. imbricata* and the small attached disks of *C. labecula* are differences in growth that will readily distinguish them from the species here described. The open mesopores, strongly arched, prominent lunaria, and radiating zoœcia present an appearance so different from associated bryozoa that this is not likely to be confused with any other species.

Occurrence.—Not uncommon in the Rochester shale at Rochester and Lockport, N. Y., and at Grimsby, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35735, 35736, U. S. National Museum.

Genus CERAMOPORELLA Ulrich.

Zoarium of incrusting layers, which by superposition may form masses; zoœcia short, tubular, with thin walls; apertures oval, oblique, the lunarium forming a hood; mesopores abundant, often completely encircling the zoœcia.

Hitherto this generic type has been supposed to have been restricted to the Ordovician, but the following species possess all of the features of the genus.

CERAMOPORELLA ORBICULATA (Ringueberg).

Pl. IX, figs. 12-15.

Ceramopora orbiculata Ringueberg, Bull. Buffalo Soc. Nat. Hist., V. 1886, p. 19, pl. 2, figs. 13, 13a.

Original description.—Habit parasitic, small, flat, discoid, central portion slightly elevated, from which point the lip of a lamination extends outward and curving backward to the outer border of the disk, showing that it increased by growing upon itself in spiral laminæ, and gives no evidence of any further lateral extension. Cells closely arranged, directed outward from the center at an oblique angle tending in the direction of the spiral growth, and have a prominent nariform calice over the upper side. Outer border of disk striate.

From the upper part of the shale.

The specimen described and figured by Ringueberg proved upon examination to be the young of a *Ceramoporella*, at first supposed by the writer to be a new species. These small incrusting disks are not uncommon in the shales, and a careful study of their zoœcial characters will usually determine their relations to older specimens. Most of the various ceramoporoids and fistuliporoids commence their growth as small incrusting disks which appear quite distinct and often seem to bear no relation to the mature form. The following are the characters of Ringueberg's species as observed in mature specimens.

Zoarium of thin parasitic incrustations seldom exceeding 0.40 mm. in thickness. Surface smooth, exhibiting at intervals of 2 to 2.5 mm. small, solid maculæ from which the zoœcia radiate. Zoœcial apertures round to oval, placed at the bottom of vestibular areas formed by thin coalescing ridges occupying the interspaces. About 10 zoœcia in 2 mm. Lunaria crescentic, small but prominent, occupying about one-sixth of the vestibular perimeter, and with the ends projecting slightly into the zoœcial cavity. The vestibular areas are polygonal in outline, usually quadrangular when the radiate arrangement is pronounced, and bear the lunaria on the angle nearest a macula.

A perfect specimen of this neat little species with its radiating zoœcia and prominent lunaria forms one of the prettiest bryozoans of this formation. The extremely small zoœcia, polygonal outline of the vestibules, small crescentic lunarium, and the radiate, almost diagrammatic arrangement of the zoœcia about the maculæ are characters which will cause this form to be easily identified.

Occurrence.—Not uncommon in the Rochester shale at Lockport, Rochester, Lewiston, and Niagara Falls, N. Y., and at Grimsby, Ontario.

Catalogue numbers, 35478, 35479, 35737, U. S. National Museum.

CERAMOPORELLA IRREGULARIS, n. sp.

Pl. IX, figs. 7-9.

Zoarium incrusting, the type specimen growing around a crinoid column and consisting of two superposed layers of zoœcia varying from one-third to 1 mm. in thickness. Zoœcial apertures direct, arranged radially about the maculæ, which are small and inconspicuous and consist mainly of mesopores. Zoœcia usually angular, 4 to 5 in 2 mm., with thin walls, the posterior one-fourth exhibiting the sharply elevated lunarium which is less overarching and more erect than usual. Mesopores rather numerous, angular, thin-walled, irregular in size and shape.

Vertical sections show that the zoœcia have a small axial region and a large peripheral zone. The walls exhibit the indefinite hazy structure transversely marked that is characteristic of the family as a whole and is known as ceramoporoid structure. A single diaphragm is inserted in some of the zoœcial tubes. Tangential sections bring out the lunarium and the irregular zoœcia and mesopores particularly.

This interesting species is closely related to the Cincinnatian form, *Ceramoporella distincta* Ulrich, but differs in having a larger and more prominent lunarium, and more irregular zoœcia and mesopores. Care must be taken to separate it from the associated *Ceramopora niagarensis*, which it resembles externally in some respects. However, upon examination with the lens, the angular, thin-walled, direct zoœcia and mesopores of the *Ceramoporella* contrast strongly with the thick-walled, oblique zoœcia and long-drawn-out lunarium of the *Ceramopora*.

Occurrence.—Rather rare in the Rochester shale at Lockport, N. Y.

Catalogue number, 35480, U. S. National Museum.

Genus CŒLOCLEMA Ulrich.

The Niagaran rocks of New York and Indiana contain several new species of ceramoporoids which in the present state of knowledge can only be referred to the Ordovician genus *Cœloclema*. These Silurian forms have several features in common which, with a careful study of this group, will probably cause them to be assigned elsewhere. *Cœloclema* was established for ceramoporoids having zoœcia as in *Ceramoporella*, but differing in that the zoarium formed hollow branches lined internally with a striated epitheca.

CŒLOCLEMA CAVERNOSA n. sp.

Pl. XXIII, figs. 10-13.

Zoarium of hollow branches varying in diameter from 2 to 5 mm., lined internally with a striated epitheca; thickness of zoarium 0.5 mm. or less. Surface without monticules but rough on account of the projecting lunaria. Maculæ small, solid, not a prominent feature. Zoœcia arranged in regularly ascending diagonally intersecting rows, measuring along one of the rows, 5 zoœcia in 2 mm. Posterior wall of zoœcia raised, long drawn out, and overarching the aperture, forming the prominent lunarium. Internal structure as in *Ceramoporella* and related genera of the Ceramoporidæ.

The only associated hollow-branched species, *Fistulipora tuberculosa* (Hall), may readily be separated from the form just described by its very small, strongly bilobed zoœcia and different internal structure.

Occurrence.—Half a dozen specimens were found in the Rochester shale at Lockport, N. Y.; rare in the Osgood beds at Osgood, Ind.

Catalogue number, 35471, U. S. National Museum.

Genus SPATIOPORA Ulrich.

Zoarium forming thin crusts, usually on *Orthoceras;* zoœcia very short, nearly direct; apertures irregular, with blunt spines at the angles, no lunarium developed; elevated, elongated maculæ usually a conspicuous feature.

The following species agrees in all respects generically and is otherwise closely related to typical Cincinnatian forms, such as *S. lineata* Ulrich.

SPATIOPORA MACULATA (Hall).

Pl. VIII, figs. 1-4; Pl. IX, figs. 10, 11.

——— ——— Hall, Nat. Hist. New York, Pal. II, 1852, pl. 40E, figs. 7a, b.
Paleschara maculata Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 8, figs. 9, 10; Ibid. (Mus. ed.), 1879, p. 121, pl. 8, figs. 9–13.
Paleschara maculata Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882, p. 246, pl. 7, figs. 9–13.
Leptotrypa maculata Ulrich, Jour. Cincinnati Soc. Nat. Hist., VI, 1883, p. 158.
Paleschara? aspera Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 8, figs. 11–13.

Several specimens were found in the Rochester shale agreeing in all respects with typical examples of the species from the Waldron shale described by Hall as *Paleschara maculata*. A study of the internal and external features of these in connection with the Waldron specimens shows that Hall's species is a *Spatiopora* with close relation to the Lorraine forms *S. maculosa* and *S. lineata* Ulrich.[a] The Niagaran form differs from both, however, in having considerably larger zoœcia. Hall has given good figures of the species and these, with a drawing of the surface and internal structure, are reproduced on Pls. VIII and IX. Old examples show the well-marked maculæ which suggested the specific name, but in young specimens the maculæ are much less conspicuous, the principal feature being the well-marked lineate arrangement of the zoœcia.

The zoarium of *S. maculata* consists of exceedingly thin expansions, generally incrusting the shells of *Platystoma*, although smooth brachiopods are sometimes selected. Zoœcia elongate, polygonal, and arranged lineately in young examples, measuring longitudinally 4 to 5 in 2 mm. and 7 in the same space transversely; hexagonal, and the lineate arrangement less pronounced in older specimens where 6 zoœcia may be counted in 2 mm. With age small spines develop until in the most mature specimens the walls inclosing a zoœcium bear from 12 to 15 of these blunt acanthopore-like structures generally found in *Spatiopora*.

Occurrence.—Waldron shale, Waldron, Ind., and Newsom, Tenn.; Rochester shale, Lockport, N. Y., and Grimsby, Ontario.

Catalogue numbers, 35461, 35462, 35463, U. S. National Museum.

Family FISTULIPORIDÆ Ulrich.

Genus FISTULIPORA McCoy.

Zoarium massive, lamellate, ramose, parasitic or free; under surface with a wrinkled epitheca; zoœcia cylindrical or somewhat compressed, direct or almost so, thin walled until near the surface, and provided usually with a few diaphragms, and encircled by one or more series of vesicles; apertures subradially arranged about the maculæ, ovoid, subtriangular or pyriform, the lunarium more or less strongly developed; surface between apertures smooth or granular.

FISTULIPORA LAMINATA (Hall).

Pl. VII, figs. 4-6; Pl. VIII, figs. 9, 10.

Callopora laminata Hall, Nat. Hist. New York, Pal. II, 1852, p. 146, pl. 40, figs. 3a-e.
Leioclema? laminatum Ulrich, Geol. Survey Illinois, VIII, 1890, pp. 416, 425.
Lioclema (*? Nicholsonella*) *laminatum* Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 304.

Professor Hall distinguished this species from the associated *Callopora* (now *Nicholsonella*) *florida* by the much smaller cell apertures, but an examination of his figured type shows that it is a specimen of a well-marked species of *Fistulipora* differing from associated forms of this genus in its laminar growth, small zoœcia, and well-developed lunarium. The zoœcia are usually trilobate in outline because of the well-developed lunarium occupying about one-third of the circumference and indenting the cavity. Five to six zoœcia may be counted in 2 mm., while the diameter of an individual zoœcium is usually 0.20 mm. In width the interzoœcial spaces average the diameter of the zoœcia and are occupied by vesicles, which

[a] Jour. Cincinnati Soc. Nat. Hist., VI, 1883, p. 167, pl. 7.

become closely arranged as the surface is approached. At the surface the vesicles are replaced by a dense calcareous deposit, which gives the solid aspect to the maculæ and interzoœcial spaces.

Compared with *Fistulipora lockportensis*, which also has a laminate growth, *F. laminata* may be readily distinguished by its much smaller zoœcia and strong lunaria. The other associated species of the genus differ so much in growth and other characters that they should not be confused.

Occurrence.—Rather uncommon in the Rochester shale at Lockport and Rochester, N. Y., and at Grimsby, Ontario.

Catalogue numbers, 35467, 35468, 35738, U. S. National Museum.

FISTULIPORA TUBERCULOSA (Hall).

Pl. VII, figs. 11-15; Pl. VIII, figs. 7, 8; Pl. XXIII, fig. 14.

Rhinopora tuberculosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 120, pl. 40E, figs. 4a-c.
Rhinopora tuberculosa Grabau, Bull. New York State Mus., No. 45, 1901, p. 175; fig. 77.

The type specimen of *Rhinopora tuberculosa* was found by the writer to be a somewhat crushed example of a *Fistulipora* having a utricular method of growth and occurring in comparative abundance in the shales. Other more perfect specimens show the following diagnostic characters:

Zoarium consisting of irregular hollow branches, with a wrinkled epitheca on the inside, averaging 5 mm. in diameter when not crushed; thickness of zoarium ranging from 0.5 to 1.0 mm. Surface exhibiting at intervals averaging 3 mm. subsolid, slightly elevated monticules from which the zoœcia radiate in distinct lines. Apertures small, elongate oval, 0.20 mm. in their longer diameter and 0.10 mm. in the shorter, 7 to 8 in 2 mm. Lunarium very prominent and overarching more than one-half the aperture. Maculæ and zoœcial interspaces occupied by angular vesicles.

The utricular form of growth, small zoœcia, and prominent lunaria are characteristic of this species and cause it to be easily distinguished from associated forms of *Fistulipora*.

Although the individual branches of this species are small, an entire zoarium is often of considerable size, one specimen in the collection of the United States National Museum being 13 cm. high and 15 cm. in breadth.

Occurrence.—Not uncommon at Lockport and other localities in western New York; Grimsby, Ontario.

Catalogue numbers, 35486, 35487, U S. National Museum.

FISTULIPORA LOCKPORTENSIS n. sp.

Pl. VII, figs. 1-3.

Zoarium forming irregular lumps made up of superposed layers 10 cm. in diameter, but more often consisting of epithecated laminar expansions 5 cm. wide and composed of layers each 1½ to 3 cm. thick. Surface rough on account of the large zoœcial apertures and exhibiting rather irregular and inconspicuous rounded monticules. The latter may be distinguished most easily by the presence of maculæ, from which the zoœcia radiate. Zoœcia in the immediate vicinity of the maculæ slightly larger and with more prominent lunaria; 4 zoœcia in 2 mm. Apertures rounded and with a distinctly elevated peristome; the posterior half more elevated and forming the lunaria, which is usually inconspicuous and seldom indents the zoœcial cavity. Maculæ and interzoœcial spaces occupied as usual in the genus by vesicles. Diaphragms usually wanting in the zoœcial tubes, although occasionally a few thin delicate ones may be developed.

The laminar or irregular growth, large zoœcia, and inconspicuous lunaria are particularly characteristic of this species. The associated *F. laminata* also has an explanate method of growth, but its much smaller zoœcia and well-developed lunaria will serve as a ready means of distinction.

Occurrence.—Not uncommon at Lockport and Rochester, N. Y.

Catalogue numbers, 35488, 35489, U. S. National Museum.

FISTULIPORA CRUSTULA n. sp. or new name.

Pl. VII, figs. 7-10; Pl. VIII, figs. 16, 17; Pl. XXIII, fig. 15.

Compare *Ceramopora incrustans* Hall, Nat. Hist. New York, Pal. II, 1852, p. 169, pl. 40E, figs. 2a-d; Grabau, Bull. New York State Mus., No. 45, 1901, p. 163, fig. 59.

Zoarium incrusting, usually consisting of a single layer and this seldom more than 1 mm. in thickness. Surface marked with conspicuous maculæ, which are sometimes elevated, but more often depressed below the plane of the zoœcial aperture. Measured from center to center the maculæ are on an average 3.5 mm. apart. Zoœcial apertures 6 to 7 in 2 mm., arranged in more or less regular series radiating from the maculæ. When the zoarium is in the youthful condition or the surface is worn, the zoœcial apertures are somewhat rounded or trilobate and are separated by mesopores; but in the perfect mature stage the zoœcial interspaces are occupied by walls or ridges, which, coalescing, form a polygonal area inclosing the aperture. Lunaria small, but well developed, appearing as a crescentic elevation at one of the angles and projecting slightly into the zoœcial cavity.

In thin sections the zoœcia are seen to be at first prostrate and then to bend almost at right angles direct to the surface. Interzoœcial spaces occupied by a considerable number of large angular vesicles, the maculæ also being simply clusters of vesicles.

The incrusting growth, well-marked maculæ, size of zoœcia, small sharply defined crescentic lunaria, and the inclusion of the apertures in polygonal areas are particularly characteristic of this species. In all probability the latter feature would cause this form to be regarded as a species of *Selenopora* Hall,[a] the distinguishing feature of this genus being the situation of the apertures in a polygonal area formed by coalescing ridges. Inasmuch as this peculiarity has been observed in other genera, notably *Ceramoporella*, the writer has deferred the reference of this and similar forms to *Selenopora* until a thorough study of the entire group can be undertaken.

The types of *Ceramopora incrustans* could not be found, but, judging from Hall's figures, that species and the one here described are apparently the same. The new name *Fistulipora crustula* is here proposed in the event of the two proving to be the same, the specific name *incrustans* having been applied to a European Carboniferous *Fistulipora*, first described by Phillips as *Calamopora incrustans*. Should Hall's types be found and differ from the specimens of *F. crustula* here described, both names will stand, unless of course *Ceramopora incrustans* proves to be a true *Fistulipora*, when another new name will become necessary.

Occurrence.—Abundant in the Rochester shale at Lockport, Niagara Gorge, and Rochester, N. Y., and at Grimsby, Ontario.

Catalogue numbers, 35481, 35482, 35483, 35556, U. S. National Museum.

Genus CHILOTRYPA Ulrich.

Small ramose *Fistuliporidæ* with a narrow irregularly contracting and expanding axial tube.

CHILOTRYPA OSTIOLATA (Hall).

Pl. VIII, figs. 11-15; Pl. IX, figs. 1-4.

Trematopora ostiolata Hall, Nat. Hist. New York, Pal. II, 1852, p. 152, pl. 40A, figs. 5a-m.
Chilotrypa ostiolata Ulrich, Jour. Cincinnati Soc. Nat. Hist., VII, 1884, pl. 3, figs. 7, 7a.
Chilotrypa ostiolata Grabau, Bull. New York State Mus., No. 45, 1901, p. 164, fig 60.
Trematopora coalescens Hall, Nat. Hist. New York, Pal. II, 1852, p. 150, pl. 40A, figs. 2a, b.
Chilotrypa? coalescens Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, p. 207.

This is probably the most abundant bryozoan of the Rochester shale, fragments being found in great numbers wherever the bryozoan beds are exposed. Often several inches or more of strata are composed almost entirely of fragments of this species. Hall and Ulrich have amply illustrated and described the species, but for the sake of completeness, and in order to give measurements, the following description is offered:

[a] Nat. Hist. New York, Pal. VI, 1889, p. xvii.

Zoarium of small ramose cylindrical stems dividing irregularly at somewhat variable distances and averaging 2 or 3 mm. in diameter. Surface smooth but exhibiting at regular intervals small, solid, slightly depressed maculæ, around which the zoœcia are somewhat larger than usual and radially arranged. Zoœcia rounded to oval, 6 in 2 mm. measuring in the direction of their greater length, 0.20 to 0.25 mm. in diameter. Zoœcial margin elevated highest posteriorly, where it forms the lunarium, but gradually diminishing toward the anterior end. Interzoœcial spaces occupied by vesicles which become filled by a dense deposit of tissue at the surface. Axial tube narrow, about 0.60 mm. wide at the most expanded portion and becoming reduced to 0.10 mm. where least expanded.

Through the kindness of Professor Whitfield the writer was enabled to examine the types of both *Trematopora ostiolata* and *T. coalescens*, with the result as indicated in the above synonymy. The type of the latter is a broad, frequently dividing branch differing otherwise in no respect from typical specimens of the former. In the writer's opinion, this species is merely the basal portion of *Chilotrypa ostiolata*. In this event the specific name *coalescens* should have precedence as its description precedes that of *Trematopora ostiolata*. However, the latter name has become so grafted into the literature that it seems unwise to change it for the hitherto practically unknown form, *T. coalescens*.

Occurrence.—Very abundant at Lockport and at all the other Rochester shale localities in New York and Canada. Also common in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35492, 44117, 35490, 35491, U. S. National Museum.

Genus MEEKOPORA Ulrich.

Zoarium of broad, bifoliate fronds, celluliferous on both faces; zoœcia with numerous diaphragms, oblique apertures, and not very prominent lunaria. The following species is the earliest known of the genus:

MEEKOPORA FOLIACEA (Hall).

Pl. VIII, figs. 5, 6; Pl. IX, figs. 5, 6.

Ceramopora foliacea Hall, Nat. Hist. New York, Pal. II, 1852, p. 170, pl. 40E, figs. 3a-c.
Meekopora foliacea Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 312.

Zoarium bifoliate, growing into thin, flat expansions sometimes as much as 40 mm. in length and breadth; thickness usually 1 mm. Surface smooth but showing conspicuous narrow, solid, elongate maculæ pointed distally and dividing, each of the divisions pointing and narrowing in the direction of growth. Apertures oblique, subcircular, 0.20 to 0.25 mm. in longer diameter and 0.15 to 0.20 mm. in shorter, directed toward the growing edge of the zoarium and arranged in rather regular, diagonally intersecting rows. Proximal part of the zoœcium slightly raised, forming the lunarium; interzoœcial spaces solid.

In vertical sections the zoœcia are seen to be at first prostrate along the axis separating the two layers and then to bend abruptly toward the surface. The interzoœcial space is here seen to be filled with vesicles which decrease in size and increase in number as the surface is approached. At and just below the surface the vesicles are obscured or replaced by a dense calcareous tissue which gives the solid aspect of the interzoœcial spaces externally.

The bifoliate growth of this form distinguishes it from all associated fistuliporoids, while the other bifoliate bryozoa are so different otherwise that specific mention of them is not necessary. Other easily recognized characters are the elongate, branched maculæ, the zoœcia with lunaria pointed distally, and the solid interzoœcial spaces. *Meekopora foliacea* is the earliest known species of the genus, and, as would be expected, has not yet developed the typical generic characters.

Whitfield and Hovey [a] in their catalogue of types and figured specimens in the American Museum of Natural History have regarded Hall's type of *Ceramopora foliacea* as identical with *Lichenalia concentrica*. From a personal examination of the types of the two

[a] Bull. Am. Mus. Nat. Hist., vol. 11, pt. 2, 1899, pp. 104, 105.

species in question, the writer is certain that this is an error. The type of the former species is bifoliate and exhibits all the characters of the specimens here described and figured as *Meekopora foliacea*, while the types of *Lichenalia concentrica* are circular, unilaminate expansions with totally different external and internal features. Comparison of the figures of the two species given on the plates of the present work will show how little allied these two forms really are.

Occurrence.—A rather abundant fossil in the Rochester shale at Lockport, Rochester, and other localities in New York, and at Grimsby, Ontario.

Catalogue numbers, 35484, 44116, U. S. National Museum.

Order TREPOSTOMATA Ulrich.

This order, which comprises the "monticuliporoids," is fairly well represented specifically in the Rochester shale. Species forming large zoaria, such as are abundant in the Mohawkian and Cincinnatian groups, seldom occur, the majority of the forms appearing dwarfed or of the small ramose type. Of the number of species so far found, Hall has described twelve, and Ulrich, Ringueberg, and Foerste one each. The remaining are here regarded as new.

Family MONTICULIPORIDÆ Nicholson (emend. Ulrich).

Genus ORBIGNYELLA Ulrich and Bassler.

Orbignyella Ulrich and Bassler, Smithsonian Miscell. Coll. (Quart. issue), XLVII, 1904, p. 18.

This genus was recently proposed by Mr. Ulrich and the writer for the reception of those species which differed from true *Monticulipora* in having curved diaphragms instead of cystiphragms, in wanting the peculiar irregularly granulose wall structure of that genus and in possessing true acanthopores.

ORBIGNYELLA EXPANSA (Ringueberg).

Pl. X, figs. 5-8.

Chætetes expansus Ringueberg, Bull. Buffalo Soc. Nat. Hist., V, 1886, p. 20, pl. 2, fig. 17.

Original description.—Corallum spreading in an irregular lamina. Cells sharply angulate, of various shapes from quadrangular to hexagonal; partitions thin; margins of partitions smooth or slightly crenate; dentate at their juncture. The oblique rhomboid cell is seen wherever a regular growth took place. Length of cells, from one-sixteenth to three-sixteenths of an inch; about ten cells to one-eighth of an inch.

Through the kindness of Doctor Ringueberg the writer was enabled to compare specimens with the type of the species. The following description is based upon the type and other well-preserved specimens and thin sections:

Zoarium of lamellate, epithecated expansions composed of one or more layers, each of which is usually several millimeters in thickness. Surface smooth, but exhibiting conspicuous clusters composed of zoœcia attaining a diameter one and one-half times as great as that of the intermacular zoœcia. Zoœcia polygonal, thin walled, 4 in 2 mm., counting from the center of a macula, or 6 of the ordinary ones in the same space; when well preserved, showing minute granulations along the walls and small acanthopores usually at the angles. Mesopores wanting. Zoœcial tubes thin walled in the short axial region, slightly thickened in the peripheral, where they contain a rather crowded series of curved diaphragms, three usually occurring in the distance of a tube diameter.

This species resembles *O. lamellosa* (Ulrich) of the Richmond of Illinois in several respects, but the smaller zoœcia of the latter (8 in 2 mm.) distinguish it at once. All of the associated lamellate forms are so different that comparison is not necessary.

Occurrence.—Uncommon at Lockport, Niagara Gorge, and Rochester, N. Y., and at Grimsby, Ontario.

Catalogue numbers, 35540, 35541, U. S. National Museum.

ORBIGNYELLA MAGNOPORA n. sp.

Pl. X, figs. 9-12.

This species resembles *O. expansa* in mode of growth, consisting of an explanate expansion composed of one or more layers of zoœcia. It is distinguished even with the naked eye by the unusually large, thin-walled zoœcia, of which there are 3 to 4 of the intermacular zoœcia in 2 mm., while *O. expansa*, although a large-celled species, has thicker walls and 6 zoœcia in the same space. The surface is smooth and the maculæ are sometimes detected with difficulty, the zoœcia being usually quite uniform in size. Walls thin; acanthopores and mesopores wanting. Diaphragms curved and developed at intervals averaging their own diameter apart.

The large zoœcia will distinguish this from all other species of the genus, as well as from associated bryozoa.

Occurrence.—The types are from Grimsby, Ontario, but the species has also been found at Lockport and Rochester, N. Y.

Catalogue numbers, 35537, 35538, 35539, U. S. National Museum.

Genus MESOTRYPA Ulrich.

Species of this genus are readily recognized by the discoid, generally free zoarium, with the zoœcial tubes crossed by curved diaphragms, and mesopores abundantly developed and closely tabulated. The following is the only species known from strata younger than the Ordovician:

MESOTRYPA NUMMIFORMIS (Hall).

Pl. X, figs. 1-4.

Callopora nummiformis Hall, Nat. Hist. New York, Pal. II, 1852 p. 148, pl. 40, figs. 5, a, b.
Calloporella? nummiformis Ulrich, Geol. Survey Illinois, VIII, 1890, p. 416.
Diplotrypa milleri Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, 1882, p. 245, pl. 11, figs. 2-2c.
Mesotrypa milleri Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 312.

Zoarium discoid, about 10 mm. in diameter and 3 mm. thick; base slightly concave, covered with a concentrically wrinkled epitheca; celluliferous side convex, smooth, with maculæ composed of larger zoœcia and more numerous mesopores distributed at intervals of usually 3 mm., but not conspicuous. Zoœcial apertures, according to the number of mesopores, polygonal or subcircular in outline; 6 to 7 in 2 mm. Zoœcial tubes crossed by curved diaphragms, irregular in distribution, varying from one to four in a tube diameter. Mesopores closely tabulated, numerous in the younger part of the zoarium, and often closing up as the surface is approached. Acanthopores apparently not present.

A comparison of the type specimens of the Rochester shale form, *Callopora nummiformis* Hall, with those of *Mesotrypa milleri* (Ulrich) from the corresponding horizon at Osgood, Ind., shows that both are founded upon the same species. Among the associated forms, *Orbignyella expansa* (Ringueberg) has curved diaphragms, but the explanate growth, absence of mesopores, and larger zoœcia readily distinguish it. The only associated discoid species, *Ceramopora imbricata* Hall, is otherwise so distinct that there is little danger of confusing the two.

Occurrence.—Rather uncommon in the Rochester shale at Lockport, Rochester, and other localities in New York, and at Grimsby and Thorold, Ontario. More abundant in the Osgood beds at Osgood, Ind., where Ulrich's types were obtained.

Catalogue numbers, 35542, 35543, 35544, U. S. National Museum.

Family HETEROTRYPIDÆ Ulrich.

Genus STIGMATELLA Ulrich and Bassler.

Hitherto this genus has been supposed to be represented only in the Ordovician, and therefore the discovery of a Silurian species is not without interest. The zoarium is extremely variable, ranging from incrusting to massive and ramose, although each particular method of growth is constant for a species. The particular generic character, however,

other than the heterotrypoid wall structure, is the development of the acanthopores in narrow zones, which occur intermittently in the zoarium. The following species exhibits this character fairly well, although not so markedly as in some of the Ordovician forms.

STIGMATELLA GLOBATA n. sp.

Pl. XIV, figs. 6-9.

Zoarium of rounded masses, globular where growth occurred about a small, short object, and elongate when the zoœcia covered a ramose bryozoan or a similar long, narrow body; the variation in length of the longer diameter in the specimens studied ranging from 10 mm. to 20 mm. Zoœcia polygonal, 7 in 2 mm., thin walled, generally in contact. Mesopores few, averaging one to a zoœcium. Acanthopores small and moderately numerous when one of the zones is cut by thin sections, but otherwise practically wanting. Diaphragms few in both zoœcia and mesopores.

The most noticeable feature in vertical sections is the development of acanthopores in zones averaging 0.35 mm. in length and occurring at intervals of 1 mm. A zoarium of some size is therefore made up of a number of such intermittent zones.

The massive zoarium, thin-walled polygonal zoœcia, and the occurrence of the acanthopores in zones will serve to distinguish this species, although care must be taken not to confound it with the similar zoaria of *Diplotrypa walkeri* and *Lioclema globulare*.

Occurrence.—Not uncommon in the Rochester shale at Lockport and Rochester, N. Y.

Catalogue number, 35769, U. S. National Museum.

Family BATOSTOMELLIDAE Ulrich.

In point of species this is the most prolific family represented in these shales, no less than fifteen forms, referred to five genera, being found. Most of the species afford excellent thin sections, in which the chief character of the family, the fused walls of the zoœcia and mesopores, is well shown.

Genus BATOSTOMELLA Ulrich.

A zoarium of slender, smooth, ramose branches with small, rounded or oval zoœcia, separated by more or less numerous mesopores and having usually very numerous acanthopores, characterizes this genus. The mesopores, however, seldom show at the surface, since with age they become filled with a calcareous tissue and the surface usually shows only solid zoœcial interspaces bearing the numerous acanthopores.

The following species, although the first of the genus in matter of time, is very similar to the Mississippian types:

BATOSTOMELLA GRANULIFERA (Hall).

Pl. XIII, figs. 1-5; Pl. XXIV, figs. 10, 11; Pl. XXV, figs. 11, 12.

Trematopora granulifera Hall, Nat. Hist. New York, Pal. II, 1852, p. 154, pl. 40A, figs. 9a–e.
Batostomella granulifera Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 180.
Batostomella granulifera Grabau, Bull. New York State Mus., No. 45, 1901, p. 164, fig. 61.

Zoarium of slender, ramose branches, usually about 2 mm. in diameter. Surface smooth, hirsute because of the numerous acanthopores. Zoœcia rounded, elongate, 8 in 2 mm. longitudinally and 10 to 11 transversely. Mesopores moderately abundant, usually closed at the surface. Acanthopores numerous, seven on an average surrounding a zoarium. Zoœcial tubes thin walled in the axial region and thickened in the peripheral, where the acanthopores and mesopores are developed, the latter closed, as the surface is approached, by a deposit of tissue. Diaphragms absent in both zoœcia and mesopores.

Several associated bryozoa, notably *Acanthoclema asperum* (Hall) and *Lioclema ramulosum* n. sp., resemble this form superficially. Under the definition of the latter their differences are indicated, while *A. asperum* may be separated externally by its smaller branches and different arrangement of the zoœcia, these in young specimens being arranged in quincunx lines and elongate-striate in old examples. Internally the two are of course quite different.

Occurrence.—Very abundant at Lockport, Rochester, Middleport, and other New York localities; Grimsby, Hamilton, and Thorold, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue number, 35517, U. S. National Museum.

Genus BYTHOPORA Miller and Dyer.

The oblique apertures drawn out anteriorly, canaliculate interspaces, and few mesopores and acanthopores characterize this genus.

BYTHOPORA SPINULOSA (Hall).

Pl. XIII, figs. 6, 7; Pl. XXIV, figs. 12–13.

Trematopora spinulosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 155, pl. 40A, figs. 11a–c.
Bythopora spinulosa Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 180.
Bythopora spinulosa Grabau, Bull. New York State Mus., No. 45, 1901, p. 166, fig. 64.

This little form is easily recognized by its narrow cylindrical branches 1 to 2 mm. in diameter, with surface smooth except that, at intervals of about 0.5 mm., sharp, conical projections 0.1 to 0.2 mm. in height are developed.

Zoœcia thin walled in the axial region, proceeding in a gradual curve to the surface, where they open obliquely; walls in the peripheral region considerably thickened. Apertures long, oval, the posterior end somewhat elevated, 7 or 8 in 2 mm. measuring lengthwise. Diaphragms and mesopores not developed. Acanthopores wanting unless the sharp projections of the surface are of the nature of these structures.

Occurrence.—Common at Lockport, Rochester, Lewiston, and Niagara Falls, N. Y.; Thorold, Hamilton, and Grimsby, Ontario.

Catalogue number, 35516, U. S. National Museum.

Genus ERIDOTRYPA Ulrich.

This long-lived generic type is well represented in the Rochester shale both in the way of species and in the comparative abundance of specimens. The characters of *Eridotrypa*, as based on the genotype *E. mutabilis* Ulrich, a Middle Ordovician species, are ramose zoaria having more or less oblique, thick-walled zoœcia with diaphragms most closely set in the earlier part of the short mature region, a variable number of mesopores with numerous diaphragms, and few small acanthopores. The Ordovician species usually possess all of the generic characters as given above, but those from later formations sometimes diverge widely from the generic definitions. *E. striata* (Hall) possesses the typical generic characters and evidently is a survivor of the *E. mutabilis* group of species. *E. spinosa*, however, differs by developing a large number of well-marked acanthopores, while *E. nodulosa* and *E. solida* vary in another direction by having diaphragms in neither the zoœcia nor mesopores, these three species in all other respects, however, being true members of the genus. This same variation is exhibited in other Silurian and Devonian species of the genus, of which six or seven have been described, and several new forms have been found. When the knowledge of the genus is more complete, it will probably be found that, although essentially the same general type of structure pertains to all, now and then species are developed with characters indicating relations to other genera. The vertical sections of *E. nodulosa* and *Bythopora spinulosa* (Hall), as figured on Pls. XI and XIII, are certainly very similar.

ERIDOTRYPA SPINOSA n. sp.

Pl. XII, figs. 1–3, Pl. XXV, fig. 15.

This fine species is readily distinguished from the described species of *Eridotrypa* and from the associated solid ramose bryozoa by its large, thick-walled zoœcia and very numerous acanthopores. The zoarium is of ramose, frequently dividing cylindrical branches about 3 mm. in thickness. The surface of the branches is smooth, the maculæ being so inconspicuous as to be detected with difficulty.

As is usual with species of this genus, the zoœcial apertures vary considerably in appearance at the surface. In young stages the apertures are elongate, the walls slightly raised posteriorly and often confluent with those of the next zoœcium, thereby giving a striate appearance to the branch. With age the apertures become more direct and polygonal, the walls ridge-shaped and thickened, and numerous blunt acanthopores appear. In the latter condition a few mesopores are observed, these usually appearing as shallow depressions between the zoœcia. Measuring longitudinally, 4 zoœcia may be counted in 2 mm.

Thin sections bring out especially the large number of acanthopores and the thick zoœcial walls characteristic of the species. They also show that the tabulation is very much like that prevailing in the typical Ordovician species of the genus, namely, that diaphragms are most abundant near the turn from the axial to the peripheral region, that they are present but less numerous in the axial region, and that they are often wanting in the outer part of the peripheral zone. The acanthopores are very large for the genus and are most frequently arranged in rows paralleling the length of the branch. Sometimes as many as fourteen are seen surrounding a zoœcium, although eight is the usual number. The mesopores are irregularly developed and are of various sizes and shapes. When seen in vertical sections they show the usual development of diaphragms. Comparisons with the associated and somewhat similar species *E. striata* (Hall) are given under the description of that form.

Occurrence.—Not uncommon in the Rochester shale at Grimsby, Ontario, rare at Lockport and Lewiston, but more abundant at Rochester, N. Y. Common in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35521, 35522, 35739, 44128, U S. National Museum.

ERIDOTRYPA NODULOSA n. sp.

Pl. XI, figs 14, 15; Pl. XXV, figs. 1-3.

Zoarium of small, slender, cylindrical, monticulated branches about 2 mm. in diameter, dividing at intervals of 10 mm. or more. The maculæ are developed sometimes as sharp tubercules, but usually as strongly elevated elongate monticules which by their confluence assume an annular or spiral arrangement. Zoœcia varying, according to the maturity of the specimen, from oval oblique in young examples to polygonal in older specimens. A few small acanthopores are sometimes observed at the surface and mature examples show mesopores to be present.

Internal characters.—Because of the very short peripheral region, tangential sections are difficult to prepare but sections of a very old example show polygonal zoœcia, large and irregular mesopores and small acanthopores. Diaphragms wanting in both zoœcia and mesopores.

The strongly monticulated zoarium distinguishes this from small ramose forms associated with it. *Trematopora tuberculosa* has a similar monticulated zoarium, but its branches are considerably larger and the external and internal features are totally different, as a glance at the figures will show.

Occurrence.—Not uncommon at Lockport and Rochester, N. Y.

Catalogue number, 35524, U. S National Museum.

ERIDOTRYPA SOLIDA (Hall).

Pl. XII, figs. 7-9, Pl. XXIV, figs. 20-23; Pl. XXV, fig. 16.

Trematopora solida Hall, Nat. Hist. New York, Pal. II, 1852, p. 153, pl. 40A, figs. 6a-e.
Homotrypa ? solida Nickles and Bassler, Bull. U. S. Geol. Survey No. 173 1900, p. 293.

This is one of the largest solid, ramose bryozoa occurring in the Rochester, and the thick cylindrical branches varying from 5 to 10 mm. in diameter, together with the smooth surface, thin-walled angular zoœcia, and few mesopores, distinguish it from the associated forms.

The specimens usually found have elongate polygonal zoœcia opening at the surface somewhat obliquely. The oldest specimen seen shows the following external and internal characters. At the surface the zoœcia are direct, thin walled, polygonal, in contact laterally, but with the angles occupied by shallow mesopores. Sections show that the zoœcial tubes are thin walled and flexuous in the axial region and but slightly thickened in the very short peripheral zone, where a few mesopores and still fewer acanthopores are developed. Not a trace of a diaphragm has been observed in either zoœcia or mesopores. Measuring lengthwise, 6 to 7 zoœcia in 2 mm.

The resemblance of this species in several respects to *Homotrypa confluens* Foerste[a] and *Homotrypa similis* Foord[b] caused Nickles and the writer to refer it as above. The two species mentioned have thin flexuous walls in the axial region and a short peripheral zone, both of which are characters of *E. solida*, but they differ in developing a short series of cystiphragms and diaphragms. In spite of this difference in tabulation, these three species have much in common and future investigations may show that *Eridotrypa* and this section of *Homotrypa* are more closely related than the classification now shows. *E. solida* is far from being a typical *Eridotrypa*, but its combination of characters seems to indicate that genus more than any other. A similar species is *Eridotrypa appressa* Ulrich from the Hamilton formation of Illinois and Iowa.

This species is so different from the associated members of the genus that comparison is not necessary. The external characters have already been pointed out and vertical fractures show the short peripheral region and absence of diaphragms very well with a hand lens. Specimens are often found crushed, the thin-walled axial region apparently not being able to stand much pressure.

Professor Hall mentions this as a rare form, but it seems to be quite abundant in the collections.

Occurrence.—Common at Lockport, Rochester, and other localities in New York; Grimsby and Thorold, Ontario.

Catalogue numbers, 35525, 35526, U. S. National Museum.

ERIDOTRYPA SIMILIS n. sp.

Pl. XII, figs. 10–14; Pl. XXVI, figs. 1, 2.

Zoarium apparently free, consisting of a short, stout basal portion obtusely pointed at the lower end and growing upward by dichotomous branching into six or more cylindrical stems, usually about 5 mm. in diameter. Surface smooth, the maculæ being inconspicuous and distinguished by having slightly larger zoœcia and more numerous mesopores than usual. Zoœcial apertures direct, varying from angular to rounded, the shape depending upon the number of mesopores present. Walls ridge-shaped at the surface and hence appearing thin, but in thin sections they are seen to be considerably thickened. Well-preserved specimens show small acanthopores at the junction angles of the walls. Mesopores numerous in the maculæ, where they isolate the zoœcia, elsewhere usually few and placed in the angles between the zoœcia. Five to 6 zoœcia in 2 mm.

The external as well as internal characters of this form are such that the species should be recognized with little difficulty. In the immature region the zoœcia are thin walled and have diaphragms distributed at intervals of about five times their own diameter. In the late immature and early part of the mature region one or more diaphragms are inserted and are placed about their own diameter apart when more than one are present. The late part of the mature region shows no diaphragms. Compared with the zoœcia, the mesopores are closely tabulated, for here the diaphragms are arranged about their own diameter apart throughout the tube length. Tangential sections show that the zoœcia are rounded polygonal in outline and that each is surrounded by a thick ring-like wall composed of fine-grained sclerenchymatous tissue. The mesopores usually have no distinct investing wall

[a] Geol. Survey Ohio, VII, 1895, p. 600.
[b] Contrib. Micro-Pal. Cambro-Sil., Canada, 1883, p. 10, pl. 2, figs. 2-2d.

like that of the zoœcia, and appear as mere openings between the zoœcia. However, sections through the mature region of aged specimens (see Pl. XII, fig. 13), in addition to rather numerous small, granular, knotty acanthopores, show thick walls encircling both zoœcia and mesopores.

The zoarial growth of this interesting species is precisely the same as that pertaining to the highly characteristic Trenton bryozoan *Eridotrypa briareus* (Nicholson).[a] Internally the two species are also similar, but the slightly larger zoœcia and larger and more numerous acanthopores of the Niagaran species will serve to distinguish them.

Occurence.—A dozen or more specimens were found at Lockport, Niagara Falls, and Lewiston, N. Y., Grimsby and Thorold, Ontario.

Catalogue numbers, 35518, 35519, 35520, U. S. National Museum.

ERIDOTRYPA STRIATA (Hall).

Pl. XII, figs. 4–6; Pl. XXIV, figs. 3–6; Pl. XXV, fig. 14.

Trematopora striata Hall, Nat. Hist. New York, Pal. II, 1852, p. 153, pl. 40, fig. 7a–d.
Trematopora ? striata Grabau, Bull. New York State Mus., No. 45, 1901, p. 167, fig. 66.

The specimens described and figured by Hall as *Trematopora striata* prove upon examination to be the basal portions of a species of *Eridotrypa* found rather frequently in the Rochester shale.

As usual in basal expansions or on old examples overgrown by a layer of young zoœcial tubes, the zoœcia of this as well as other species of *Eridotrypa* are oblique and drawn out anteriorly. This seems to be a more permanent character in *E. striata* than in other species, and suggested the specific name.

The base of *E. striata* is seldom found, the more abundant specimens being fragments of the slender branching zoarium. The specimen figured on Pl. XXV is typical and shows the character of the species.

Internally *E. striata* differs little from the typical species of the genus. Indeed, in all features this Niagaran form is very close to the Ordovician species *E. mutabilis*. Compared with associated bryozoa, *E. striata* resembles *E. spinosa*, but the smaller zoarium, smaller zoœcia (6 in 2 mm.), and the few small acanthopores of the former will serve to distinguish the two forms.

Occurrence.—Common in the Rochester shale at Lockport, Niagara Falls, and Rochester, N. Y., and at Grimsby, Ontario. Also rather abundant in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35545, 44132, U. S. National Museum.

Genus LIOCLEMA Ulrich.

Although this genus reached its highest development specifically in later rocks, the Rochester shale affords a good representation. Individuals of the various species found here occur usually quite frequently, *L. asperum* and *L. multiporum* being particularly abundant, *L. ramulosum* being not uncommon among the small ramose forms, and *L. explanatum* and *L. circinctum* occurring least often. Some of these have a wide geographical distribution, the three first mentioned occurring also in Indiana.

LIOCLEMA ASPERUM (Hall).

Pl. XI, figs. 1–3; Pl. XXIV, figs. 14–16.

Callopora aspera Hall, Nat. Hist. New York, Pal. II, 1852, p. 147, pl. 40, figs. 4 a–i.
Lioclema asperum Ulrich, Geol. Survey Illinois, VIII, 1890, pp. 416, 425.
Lioclema aspera Grabau, Bull. New York State Mus., No. 45, 1901, p. 165, fig. 63.

Zoarium incrusting foreign bodies, forming, by the superposition of several layers, round or irregular masses, or, by growth upon ramose bryozoa or other cylindrical objects, rounded branches. Layers varying from 0.5 to 1.5 mm. in thickness; surface smooth, but, when well preserved, hirsute from the abundance of acanthopores. Maculæ of slightly larger zoœcia and more abundant mesopores but not a conspicuous feature.

[a] *Chætetes briareus* Nicholson, Geol. Survey Ohio, Pal., II, 1875, p. 202, Pl. XXI, figs. 13–13b.

Zoœcia thin walled, 6 in 2 mm., polygonal to rounded, the outline depending upon the number of mesopores intervening. Mesopores open at the surface, numerous, and because of their frequency the zoœcia are seldom in contact. In the maculæ often three rows of mesopores separate adjoining zoœcia. Acanthopores large and numerous, 3 to 5 usually encircling a zoœcium and often indenting the zoœcial cavity, thus giving a petaloid appearance seen at the surface and in sections.

Internal characters.—This species affords very pretty thin sections, the tangential especially so when showing the full development of acanthopores and mesopores. In such a section the acanthopores are seen to be large, sometimes as much as 0.1 mm. in diameter, and to show the central canal distinctly. Zoœcia as a rule 0.20 mm. in diameter and with walls slightly thicker than those of the mesopores. Vertical sections indicate that the axial region is short and the bend to the peripheral often quite abrupt. With the inception of the latter region mesopores are developed. Diaphragms are practically wanting in the zoœcial tubes, but are quite abundant in the mesopores, being placed at intervals varying from one-half to a whole tube diameter. Some of the numerous acanthopores are cut by vertical sections which show clearly the internal features of these structures.

The incrusting habit of growth, smooth surface, size of zoœcia, abundant and unusually large, conspicuous acanthopores and numerous mesopores cause this species to be easily identified. The only form with which it might be confused is the associated and very abundant *L. multiporum*, but the latter has much smaller zoœcia and unusually numerous, small mesopores and acanthopores to distinguish it, irrespective of the different internal structure. Certain forms of *L. asperum* resemble the two lamellate species *L. circinctum* and *L. explanatum*. The similarity, however, is only in method of growth, the other specific characters being quite different.

Occurrence.—Abundant in the Rochester shale at Lockport, Rochester, Niagara Gorge, and near Lewiston, N. Y., and at Grimsby, Ontario. Not uncommon in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35504, 35505, 44124, U. S. National Museum.

LIOCLEMA EXPLANATUM n. sp.

Pl. XIII, figs. 8–10; Pl. XXVI, fig. 4.

Zoarium, a laminar expansion composed of a single layer varying from several millimeters to a centimeter or more in thickness, or a more or less rounded mass formed of several superposed layers; under surface concentrically wrinkled; upper surface celluliferous, smooth, with maculæ inconspicuous. Zoœcia subcircular, those in the intermacular spaces averaging 0.25 mm. in diameter and about five occurring in 2 mm. Mesopores large, rather numerous, and usually isolating the zoœcia. Acanthopores small, inconspicuous, and generally seen only in thin sections; few in number, an average of two to a zoarium, although sometimes as many as four may be present.

The principal internal characteristic of this species is the loose tabulation of both the zoœcial tubes and the mesopores and in this respect *L. explanatum* differs from all the associated forms of *Lioclema*. In the zoœcia the diaphragms vary in distance from each other from a tube diameter to three or more times that dimension. The same variation is exhibited in the mesopores, but because of their narrower diameter these appear more closely tabulated.

The laminar growth, large zoœcia, and comparatively few and small acanthopores, distinguish this species externally from the associated forms of the genus, while the internal characters, as mentioned above, are quite different from any of the other species. Associated laminar species, such as *Nicholsonella florida* (Hall), will not be confused because of their floriform apertures and solid interzoœcial spaces. Probably the closest ally is *L. asperum*, but the different tabulation, larger zoœcia, explanate growth, and especially the much less numerous and smaller acanthopores, are points of difference.

Occurrence.—Rochester shale, not uncommon at Rochester, N. Y. Osgood beds, rare at Osgood, Ind.

Catalogue number, 35503, U. S. National Museum.

LIOCLEMA CIRCINCTUM n. sp.

Pl. XIII, figs. 11-14.

The growth of this beautiful species is the same as that of *L. explanatum*, consisting of several laminæ growing upon each other and producing an expansion several centimeters in diameter and three or four millimeters in thickness. Celluliferous surface smooth, under surface covered with a wrinkled epitheca. Zoœcia isolated from each other by at least one row of numerous small mesopores, sometimes by two or three rows, while in the maculæ four or five rows may be found separating the zoœcia, which here are a trifle larger than usual. Because of the number and small size of the mesopores the outline of the zoœcia varies from many sided to approximately circular, the latter shape occurring more frequently. An average zoœcium is 0.18 mm. in diameter; 6 in 2 mm. Mesopores small, polygonal, as many as fourteen sometimes observed bordering a zoœcium. Acanthopores apparently wanting. Diaphragms developed at intervals of a tube diameter or less in the mesopores but wanting in the zoœcia. Tangential sections when viewed under a high power show the finely granulose wall structure figured on Pl. XIII.

The small numerous mesopores isolating the zoœcia, absence of acanthopores, and explanate zoarium will distinguish this fine species. *L. explanatum*, although similar in growth, is readily distinguished by its acanthopores, larger zoœcia, larger and fewer mesopores, and different tabulation of both zoœcia and mesopores. The other species of the genus are so different that comparisons are hardly necessary.

Occurrence.—Rochester shale, rare at Lockport, N. Y.

Catalogue number, 35509, U. S. National Museum.

LIOCLEMA MULTIPORUM n. sp.

Pl. XI, figs. 4-6; Pl. XXIII, fig. 18; Pl. XXVII, fig. 20.

This species resembles *L. asperum* in habit of growth, but under a hand lens is easily distinguished by having much smaller zoœcia and an unusually large number of small acanthopores and mesopores. The surface is smooth and the maculæ are composed chiefly of mesopores. The zoœcia are irregularly rounded or floriform in outline because of the numerous acanthopores indenting their walls. An average zoœcium is 0.17 mm. in diameter and seven zoœcia may be counted in 2 mm. Mesopores small, two or three rows usually isolating the zoœcia, although in the maculæ seven or eight rows may be counted. Acanthopores small, very numerous, seven or eight often encircling a zoœcium, and many developed among the mesopores.

Internally *L. multiporum* exhibits a marked difference from *L. asperum*, in that diaphragms are almost entirely wanting in both zoœcia and mesopores, and in that the walls of the peripheral region are considerably thickened. Fossils incrusted by this species often also bear expansions of *L. asperum*, and such specimens exhibiting the two forms side by side show the specific differences very clearly.

All of a small lot of specimens collected at the same locality at Rochester, N. Y., showed a departure from the usual method of growth in that their zoaria rose into dwarfed branches. Here apparently the conditions were such as to allow an erect zoarium to develop.

Occurrence.—An abundant species in the Rochester shale, the types being from Lockport, but Rochester, Niagara Gorge, and near Lewiston, N. Y., and Hamilton and Grimsby, Ontario, furnish many specimens. Specimens are also found, although more rarely, in the Osgood beds outcropping near Waldron, Ind.

Catalogue numbers, 35501, 35502, 44122, U. S. National Museum.

LIOCLEMA RAMULOSUM n. sp.

Pl. XI, figs. 11-13; Pl. XXV, figs. 9, 10.

Probably *Callopora* n. s. Hall, Nat. Hist. New York, Pal. II, 1852, pl. 40, figs. 6 a, b.

This neat form is easily distinguished from the associated species of *Lioclema* by its ramose habit of growth and few but large acanthopores. The branches are cylindrical, 2 to 3 mm. in diameter, and divide at intervals of about 10 mm. Surface smooth. Zoœcia thin-walled, elongate polygonal or rounded, averaging 0.20 mm. in length, 0. 12 mm. in width, and measuring lengthwise 7 in 2 mm.; isolated from each other by one or two rows of open, angular mesopores. Acanthopores few, but quite conspicuous, about 1 to each zoœcium and arranged with a certain amount of regularity among the mesopores. Zoœcial tubes thin walled and somewhat flexuous in the axial region, but becoming thickened in the peripheral region. Diaphragms wanting in both regions of the zoœcia and seldom if ever developed in the mesopores.

To the unaided eye this species is identical with the associated *Batostomella granulifera* (Hall), but with a hand lens the two are easily separated; *L. ramulosum* by the open mesopores and few large acanthopores, and *B. granulifera* by its very numerous acanthopores and closed mesopores. Internally the two are also quite different.

Occurrence.—Not uncommon in the Rochester shale at Lockport, N. Y., and Grimsby, Ontario. Rare in the Osgood beds near Waldron, Ind.

Catalogue numbers, 35508, 44125, U. S. National Museum.

LIOCLEMA GLOBULARE n. sp.

Pl. XXVII, figs. 18, 19.

Zoarium a rounded mass about 10 mm. in diameter. Zoœcia polygonal, almost circular when the mesopores are more numerous than usual, larger than associated species of *Lioclema*, 5 occurring in 2 mm., and the average diameter being 0.30 mm. Mesopores small but sometimes numerous enough to isolate the zoœcia. Acanthopores few and inconspicuous, rarely seen at the surface, and determined with certainty only in thin sections. Diaphragms wanting in the zoœcial tubes and developed at irregular intervals in the mesopores.

Although the large zoœcia, few acanthopores, and globular method of growth will serve to distinguish this from the associated species of *Lioclema*, still care must be exercised to separate it from *Diplotrypa walkeri*. In growth, size of zoœcia, and number of mesopores, as well as other external features, the latter species is precisely the same, but thin sections show the different generic relations. In *D. walkeri*, however, the mesopores have straight walls and are crossed by closely set, regularly arranged diaphragms, while the walls of *L. globulare* are indented wherever diaphragms are inserted, thus giving a beaded appearance to the mesopore. In addition, the diaphragms of *L. globulare* are irregular in shape, number, and placement. A vertical fracture therefore will serve to distinguish the zoaria of the two species, *L. globulare* showing no diaphragms in the zoœcia and irregularly spaced diaphragms in the beaded mesopores, and *D. walkeri* exhibiting diaphragms in both zoœcia and mesopores, closely placed in the latter.

Occurrence.—Rare in the Rochester shale at Lockport, N. Y.

Catalogue number, 35771, U. S. National Museum.

LIOCLEMA PECULIARE n. sp.

Pl. XXIII, figs. 19-22; Pl. XXV, fig. 13.

A number of specimens of *Lioclema* have been found in the collections from Lockport and other Rochester shale localities that differ from the associated species of the genus particularly in that the walls of the zoœcia show at the surface a row of small crowded granular-like acanthopores. An examination with a hand lens will thus readily determine this form, but other points of difference are the thin-walled zoœcia and unusually few mesopores. The following description is believed to contain the more important characters.

Zoarium incrusting, species of *Atrypa* being selected most often, but other brachiopods, bryozoa, or trilobite tests also observed to have been grown upon by this species. These incrustations are generally thin and seldom consist of more than two superposed layers, each averaging 0.6 mm. in thickness. Surface smooth, maculæ inconspicuous. Zoœcia polygonal, 7 in 2 mm., with thin walls. Mesopores usually few, seldom numerous enough to isolate the zoœcia. Internally as well as externally the most striking feature is the crowded row of small granules or acanthopores which occupy the zoœcial wall. These are particularly well shown in tangential section but are also generally to be seen at the surface. Acanthopores of the size and shape usually seen in species of *Lioclema* seem to be entirely absent.

Occurrence.—Rochester shale, Lockport and other localities in New York. Rare in the Osgood beds at Osgood, Ind.

Catalogue number, 35770, U. S. National Museum.

Genus LIOCLEMELLA Foerste.

Zoœcial structure much as in *Lioclema* but the zoarium consists of cylindrical, fusiform or branched stems pointed at the base for articulation.

LIOCLEMELLA MACCOMBI n. sp.

Pl. XI, figs. 7-10; Pl. XXV, figs. 5-7.

Zoarium of slender, smooth, unbranched, cylindrical stems, 1.5 to 2 mm. in diameter and reaching a length of 30 mm., pointed at the proximal end for articulation with a base attached to foreign objects. Short examples are thickest and rounded at the distal extremity while long specimens have their greatest diameter about the middle and taper gradually toward each end. Zoœcia thin walled, angular, 6 in 2 mm. Mesopores variable in number, generally small and few, but sometimes so numerous as to isolate the zoœcia. Well-preserved mature specimens exhibit small, but well-marked acanthopores occupying the junction angles of the zoœcia. Vertical sections show that the zoœcial tubes proceed to the surface in a gentle curve and that the diaphragms seem to be restricted to the axial region, where they vary from one-half to two tube diameters in distance from each other. In the mesopores the diaphragms are about their own diameter apart. Tangential sections exhibit the small acanthopores occupying the junction angles.

Compared with described species of *Lioclemella*, *L. maccombi* resembles, especially in mode of growth, *L. fusiformis* (Whitfield) and *L. subfusiformis* (James) from the Richmond formation, and *L. ohioensis* (Foerste), a Clinton species, but differs from each in having decidedly larger zoœcia and few mesopores. When complete, the shape of the zoarium distinguishes this species from associated forms, but small fragments sometimes bear a great resemblance to similar specimens of *Eridotrypa striata* (Hall). The latter species, however, branches frequently and fragments usually show a bifurcation, while the zoœcia also are usually quite elongate. Fragments of *L. maccombi* do not branch, usually taper slightly, and have thin-walled polygonal zoœcia.

This fine species is named in honor of Mr. George T. McComb, of Lockport, N. Y., who by collections has generously aided the writer in making this paper as complete as possible.

Occurrence.—Not uncommon in the washings and on slabs from the Rochester shale at Lockport, Lewiston, and Niagara Falls, N. Y., and Grimsby and Hamilton, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35535, 35536, U. S. National Museum.

Family AMPLEXOPORIDÆ Ulrich.

Genus RHOMBOTRYPA Ulrich and Bassler.

The quadrate shape of the zoœcia in the axial region is especially characteristic of this genus. This feature is best observed at the ends of the branches.

RHOMBOTRYPA SPINULIFERA n. sp.

Pl. X, figs. 13-16; Pl. XXV, fig. 21.

Zoarium small, ramose; branches slender, cylindrical, about 3 mm. in diameter, dividing at intervals of 10 mm. or more; surface smooth, macula not a conspicuous feature, and composed of mesopores and of zoœcia slightly larger than usual. In mature specimens the zoœcia at the surface are thin walled, rounded to elongate polygonal in outline and separated from each other, sometimes entirely but usually only laterally, by mesopores. Mature specimens also show small acanthopores rather regularly distributed and about one to each zoœcium. In young specimens the zoœcia are rhomboidal in shape and arranged regularly in quincunx lines.

Tangential sections show that the mesopores are quite variable in number and shape and that the spines of the surface are of the nature of true acanthopores; 6 to 7 zoœcia in 2 mm., measuring longitudinally, and transversely 10 to 11 rows in the same space. Transverse sections show the zoœcia to be quadrate in outline in the axial region, 11 to 12 in 2 mm. In the axial region of vertical sections the zoœcial walls are thin and become but slightly thickened in the peripheral; diaphragms wanting entirely in the zoœcia and very few in the mesopores. Vertical sections also indicate that new tubes are interpolated at approximately the same level. Vertical fractures also bring out this fact by showing alternate zones of smooth sides and of rough edges, the zoœcial tubes exhibiting in the first instance the flat sides of their walls, and in the latter case exposing their angles. In order to accommodate new zoœcia this turning about of the tubes in the axial region becomes necessary because of their quadrate shape. These zones of turnings are concentric and occur at intervals of about 0.7 mm.

By a glance at the quadrate zoœcia exposed at the end of a branch one distinguishes this neat species from associated small ramose forms. The presence of acanthopores separates it from other species of the genus.

Hitherto this type of monticuliporoids has been supposed to have been confined to the Richmond formation, the type of the genus, *R. quadrata* (Rominger) being a very characteristic fossil of these rocks. The discovery of the species just described in younger rocks is therefore of considerable interest.

Occurrence.—Rather rare in the Rochester shale at Lockport, where the type specimen was found, and at Thorold, Ontario, but not uncommon at Rochester, N. Y. The species has also been noted in comparative abundance in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35594, 35595, U. S. National Museum.

Family CONSTELLARIIDÆ Ulrich.

Genus NICHOLSONELLA Ulrich.

The following two species are apparently the last representatives of this genus, which is identified for the first time in the Silurian system. As might be expected, both differ in some respects from the typical Ordovician species, but the general aspect of each is such that *Nicholsonella* seems the only genus to which they can be referred with some certainty. Both develop the peculiar character of *Nicholsonella*, namely, that with age the walls of the mesopores become obscured by a calcareous deposit filling the interzoœcial spaces. Indeed, the walls of the zoœcia and mesopores have an indefinite structure throughout the mature region that is in marked contrast with the clear-cut walls of *Lioclema*, to which genus both species had formerly been referred.

NICHOLSONELLA FLORIDA (Hall).

Pl. XIV, figs. 10, 11; Pl. XXIV, figs. 1, 2.

Callopora florida Hall, Nat. Hist. New York, Pal. II, 1852, p. 146, pl. 40, figs. 2a–f.
Leioclema floridum Ulrich, Geol. Survey Illinois, VIII, 1890, pp. 416, 425.
Lioclema florida Grabau, Bull. New York State Mus., No. 45, 1901, p. 165, fig. 62.
Lioclema (? *Nicholsonella*) *floridum* Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 304.

Zoarium an explanate expansion varying from 3 to 10 mm. in thickness and sometimes attaining a width of 50 mm., although the specimens are usually seldom over 25 mm. wide. Base marked with a wrinkled epitheca. Celluliferous surfaces without monticules, even, the maculæ being inconspicuous and composed of groups of zoœcia of the normal size but separated by interspaces slightly wider than usual. Zoœcia large, rounded, two to three in 2 mm., and on an average slightly less than 0.5 mm. in diameter. Apertures floriform, the acanthopores inflecting the zoœcial walls which encroach upon the zoœcial cavity. Interzoœcial spaces open in young specimens and showing one or two rows of mesopores separating adjoining zoœcia, but in old specimens closed with a solid, granulose deposit. Acanthopores large, numerous, averaging four or five to each zoœcium, and inflecting the walls so as to give the floriform or petaloid appearance to the zoœcial aperture.

Internal characters.—Carefully prepared vertical sections show a very short, immature region in which the zoœcia are prostrate, and although their walls are of a clearer structure than that obtaining in the mature zone, even here their indistinct nature is clearly shown. With the inception of the mature region, the bend to which is quite abrupt, mesopores and acanthopores are developed. Here the wall structure already noted becomes still less distinct, and, finally, in the older parts of the zoarium, the walls of the zoœcia, and especially of the mesopores, become obliterated by a deposit of granular tissue. Diaphragms are inserted in the zoœcial tubes at an average distance apart of a trifle less than their own diameter. The diaphragms of the mesopores are at a like distance from each other, but because of their narrower diameter appear more crowded.

As is usual in most Trepostomata, the diaphragms are more abundant in the later than in the earlier parts of the mature region. The acanthopores of this and of the following species are quite different from the normal form of this structure, as they are seen in vertical sections to be simply tubes with a more or less definite wall inclosing a central clear space. No trace of the usual laminated tissue arranged in cone-like layers and pierced vertically by a central canal can be observed.

Tangential sections present various appearances, according to the portion of the zoarium cut by them. At the beginning of the peripheral regions the walls of the zoœcia and mesopores are thin and although hazy in structure are still fairly clear. Here the acanthopores are small and inconspicuous. Higher up in the mature region the walls are considerably thickened and the acanthopores have increased in size and number. Finally, in the most mature or aged condition, the interzoœcial space is occupied by a granular tissue obscuring the mesopores and through which the acanthopores pierce.

The large, rounded, isolated zoœcia, floriform apertures, closed interspaces, numerous acanthopores, and explanate growth, are characters which make the identification of this species quite easy. The closely related form *N. ringueberyi* n. sp. is distinguished by the presence of much smaller zoœcia. *Lioclema explanatum* has a similar method of growth but the smaller zoœcia and open mesopores are points of difference distinguished by the unaided eye. Internally the two are also quite different as their respective generic references indicate.

Occurrence.—Not uncommon in the Rochester shale at Lockport, Rochester, Niagara Falls, and Lewiston, N. Y.; Grimsby and Thorold, Ontario; Osgood beds, Osgood, Ind. Specimens that can not be distinguished from the typical New York form occur in the Silurian strata of the island of Gotland.

Catalogue numbers, 35510, 35511, U. S. National Museum.

NICHOLSONELLA RINGUEBERGI n. sp.

Pl. XIV, figs. 12, 13.

The various collections from the Rochester shale have shown half a dozen specimens of a species of *Nicholsonella* agreeing with the associated *N. florida* in method of growth but differing decidedly in the size of the zoœcia and in several internal characters. This form, for which the name *Nicholsonella ringuebergi* is proposed, has seven zoœcia in 2 mm., a feature in marked contrast with *N. florida*, which has two to three in the same space. The average zoœcium of *N. florida* is 0.50 mm. in diameter, while that of *N. ringuebergi* is only 0.23 mm. Internally the absence of diaphragms in the zoœcial tubes will further distinguish the present species from the associated form.

This neat species is named in honor of Dr. E. N. S. Ringueberg, of Lockport, N. Y., in appreciation of his work on the paleontology of the Rochester shale. The small, floriform apertures, many acanthopores, and the explanate growth will readily distinguish this from other bryozoa of this region.

Occurrence.—Rather uncommon at Lockport, N. Y.

Catalogue number, 35493, U. S. National Museum.

Genus IDIOTRYPA Ulrich.

Idiotrypa Ulrich, Jour. Cincinnati Soc. Nat. Hist., VI, 1883, p. 272.
Idiotrypa Miller, North American Geol. and Pal., 1889, p. 310.
Idiotrypa Ulrich, Geol. Survey Illinois, VIII, 1890, p. 375.
Idiotrypa Simpson, Fourteenth Ann. Rept. State Geol. New York for 1894, 1897, p. 591.

This genus was established by Ulrich for the reception of a single species, *I. parasitica*, from the Osgood beds of the Niagaran of Indiana. The genus was supposed to differ fundamentally from all trepostomatous genera in that the zoarium was not clearly differentiated into mature and immature regions. Further, the development of the tabulæ at equal distances from each other in both zoœcia and mesopores seemed so much at variance with that obtaining in the monticuliporoids as then known that the systematic position of the genus appeared more doubtful. The peculiar tabulation Ulrich held to be essentially comparable with that characterizing *Cumulipora*, a Cretaceous genus of the Chilostomata, which agrees further with *Idiotrypa* in having similarly perforated diaphragms. Subsequently this author recognized the true affinities of the genus by allying it with *Constellaria* and *Nicholsonella*.[a]

Idiotrypa parasitica occurs rarely at the Indiana locality, but a number of specimens identical with Ulrich's species have been found at Lockport and other New York localities. The sections figured by Ulrich were prepared from a mature example in which the peculiar tabulation and pores are developed to the utmost. These sections also happened not to show an immature region. On Pls. XVII and XXIV Ulrich's figures and also other views of the internal characters of the species are reproduced, and the latter especially show that the genus is a true member of the Trepostomata, differing decidedly from other genera of this suborder only in development of diaphragm in both zoœcia and mesopores at frequent and equal distances. The structure of the zoœcia and mesopores otherwise is precisely like that characterizing the Constellariidæ several species of *Nicholsonella* especially showing very similar pores or foramina penetrating the walls and mesopores. Indeed, the genus is so near *Nicholsonella* that the only important difference seems to be the equal development of diaphragms in both zoœcia and mesopores.

[a] Geol. Survey Illinois, VIII, 1890, p. 375.

IDIOTRYPA PUNCTATA (Hall).

Pl. XVII, figs. 4-10; Pl. XXIV, figs. 17-19.

Trematopora ?? punctata Hall, Nat. Hist. New York, Pal. II, 1852, p. 151, pl. 40A, figs. 4a–c.
Idiotrypa parasitica Ulrich, Jour. Cincinnati Soc. Nat Hist., VI, 1883, p. 273, pl. 13, figs. 1-1c.
Idiotrypa parasitica Simpson, Fourteenth Ann. Rept. State Geol. New York for the year 1894, 1897, p. 591, figs. 187-189

As indicated by the above synonymy, Ulrich's *Idiotrypa parasitica* is identical with Hall's *Trematopora ?? punctata*. This fact could not be established with certainty by comparison with the published descriptions and figures of Hall's species, but a study of thin sections prepared from the original type of *T. punctata*, left no doubt in the writer's mind as to their identity.

Mr. Ulrich has given a careful description of his species and the portion agreeing with the present view is reproduced below:

Zoarium consisting of parasitic expansions, of variable thicknesses, usually attached to ramose bryozoa, but sometimes growing upon other foreign bodies. The true zoœcia have circular apertures, often closed by centrally perforated opercula, of an average diameter of one one hundred and twentieth of an inch, surrounded by a slightly elevated, thin, granulose, peristome. They are arranged with considerable regularity in series, in which from eight to ten may be counted in the space of 0.1 of an inch. The intertubular spaces are of somewhat variable thickness, and usually appear to be solid: occasionally, however, the mouths of shallow interstitial depressions may be observed. The spiniform tubuli usually do not constitute a conspicuous external feature.

Tangential sections show that the walls of the true cells are marked by a dark circular band, equivalent to the peristome surrounding the apertures. Within this band may be noticed, besides a limited number of rather thin-walled spiniform tubuli, a large number of smaller circular structures, usually provided like the spiniform tubuli, with a very minute lucid central spot. These doubtless represent the granules above stated to occur on the peristome in well-preserved examples. The visceral cavities of all the cells appear to be more or less filled by sclerenchyma. This is due to the fact (shown in vertical sections) that the horizontal partitions are thicker at their junction with the walls of the tubes than they are more centrally, the cavities left between them being, therefore, of lenticular form. Some of the true zoœcia show a central, obscurely circumscribed area that may represent the openings of opercula of previous layers. These sections show further that whenever the horizontal partitions are brought to light a large number of concentrically arranged dark or lucid spots may be detected, which in the true cells gradually increase in size toward the circumference.

Vertical sections show that a very short immature zone is present in which the zoœcial walls are thin and diaphragms practically wanting. With the inception of the mature zone the mesopores develop, the wall of both zoœcia and mesopores become greatly thickened, and diaphragms are inserted at frequent and equal intervals in each.

Idiotrypa punctata is so different from all associated bryozoa that confusion with other species will hardly occur.

Occurrence.— Not uncommon in the Rochester shale at Lockport, Rochester, and other New York localities. Less abundant in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35496, 35497, 43674, U. S. National Museum.

Family CALLOPORIDÆ Ulrich.

Genus CALLOPORA Hall.

This is one of the best-characterized genera of trepostomatous bryozoa. Its species are usually represented by an abundance of specimens, and, having a wide distribution geographically and a limited range geologically, are good horizon markers. The diagnostic characters of the genus are the ramose habit of growth, the rounded or angular zoœcia and more or less numerous mesopores, the absence of acanthopores, and especially the method of tabulation. The mesopores are always closely tabulated, the zoœcia less so, but have the diaphragms inserted in the following order: With the inception of a zoœcium numerous diaphragms are developed and continue in the same abundance until the tube has reached the normal size; then in the rest of the axial region diaphragms are less common, indeed sometimes almost wanting entirely, but when the peripheral zone is reached their number increases again. Compared with other genera the zoœcia attain their normal

size slowly, and this causes a transverse section to show two well-defined sets of tubes, the large set circular, representing the zoœcia of normal size, and the small of angular, variously shaped cells indicating zoœcia in different stages of development. This latter character enables one to distinguish a Callopora by merely examining the end of a branch with a lens. The size of the matured zoœcia and the shape and number of those still developing are often good specific characters.

The Silurian species of *Callopora* differ from the numerous Ordovician forms in having unusually large, conspicuous zoœcia. This characteristic pertains to all of the Calloporas known in these strata with the exception of a new species found in the Clinton at Hamilton, Ontario, which is of the Ordovician *C. ramosa* type. For the purpose of comparison these large-celled forms may be divided into two groups, the first typified by the genotype *C. elegantula* Hall and the second with *C. magnopora* Foerste as the representative form. The first group is characterized by large rounded zoœcia with numerous mesopores, and includes, besides *C. elegantula*, *C. perelegans* Hall from the New Scotland beds of New York, *C. nana* Nicholson from the Wenlock of England, and a few undescribed species or varieties closely related to the genotype. Of the second group, only *C. magnopora* has been described. *C. clausa*, a new species described in this paper, belongs to this section, while at least one undescribed form is known. The peculiarity of the group is that at the surface the mesopores are reduced almost to a minimum, the zoœcia as a result being angular and contiguous.

CALLOPORA ELEGANTULA Hall.

Pl. XVII, figs. 11-15; Pl. XXVI, fig. 12.

Callopora elegantula Hall, Nat. Hist. New York, Pal. II, 1852, p. 144, pl. 40, figs. 1a-m.
Callopora elegantula Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, 1882, p. 250, pl. 11, figs. 6-6b.
Callopora elegantula Grabau, Bull. New York State Mus., No. 45, 1901, p. 167, fig. 67.

This beautiful species well deserves to be the type of the fine genus *Callopora*. The species is widely distributed geographically and is easily recognized. Professor Hall figured the macroscopic characters quite fully and later Mr. Ulrich gave views of the internal structure. The following description sums up the specific characters:

Zoarium ramose, of frequently branching stems 3 to 5 mm. in diameter; surface smooth, the maculæ distinguished by the presence of zoœcia slightly larger than the average and of mesopores more abundant than usual. Zoœcia thin walled, rounded, 4 to 5 in 2 mm., separated by a variable number of angular, thin-walled mesopores, which are often numerous enough to isolate the zoœcial tubes. Zoœcial apertures closed in the perfect state by ornamented covers or opercula having a central circular perforation with a diameter about two-fifths that of the zoœcia. Six to eight well-marked ridges distributed at equal distances from each other radiate from the central opening to the margin.

Tangential sections bring out the circular thin-walled zoœcia separated by the numerous angular mesopores of variable size and shape. Because of the numerous mesopores the dark divisional line between adjoining zoœcia is seldom observed. The striking feature of vertical sections is the difference in tabulation between the zoœcial tubes and the mesopores. In the early stages of the zoœcia the diaphragms are closely set and continue so until the tube has reached the normal diameter. Then diaphragms are inserted at intervals of about a tube diameter until the peripheral region is reached, when they become more abundant again. The mesopores, which are developed only in the peripheral region, are closely tabulated, two diaphragms usually occurring in a space equaling the mesopore's diameter. The tabulation of the mesopores and of the early part of the zoœcia is identical and it is probable that these two regions were occupied by similar zooids. Transverse sections show the usual two sets of zoœcia, the one, large and rounded, representing the zoœcia that have reached the normal size, and the other, small, unequal, and angular, representing the younger zoœcia in various stages of development.

No difficulty will be experienced in separating *Callopora elegantula* from all associated bryozoa, the small, rounded stems with large, circular zoœcia and numerous mesopores making the species easy of recognition. The new species next described as *C. clausa* has

a similar method of growth, but the few mesopores and polygonal zoœcia distinguish it without considering the different internal characters. The representative of *C. elegantula* in Europe seems to be the form described by Nicholson in 1884 from the Buildwas beds of the Wenlock as *Callopora nana*.[a] Indeed, the two species are so closely related that the writer can not point out any satisfactory means of distinguishing them. Internally the two are alike and externally the only difference noted is that the average diameter of the zoarial branches of *C. elegantula* is about twice that of the European species. This, however, is a minor character and further investigation will probably show that *C. nana* can scarcely be regarded as more than a variety of *C. elegantula*.

Occurrence.—Very abundant in the Rochester shale at Rochester, Lockport, Niagara Falls, and other localities in New York, and at Grimsby, Hamilton, and Thorold, Ontario. Also abundant in the Osgood beds of the Niagaran at Osgood and Waldron, Ind. The species is also found in Niagaran strata at numerous points in the Mississippi Valley.

Catalogue numbers, 35534, 35533, 44129, 35528, U. S. National Museum.

CALLOPORA CLAUSA n. sp.

Pl. XV, figs. 9-12.

This neat little species agrees with *C. elegantula* in growth and general characteristics, but differs in the following respects: Mesopores are almost entirely wanting at the surface, the few that are present being usually restricted to the maculæ. As a result, the zoœcia are polygonal in outline and contiguous. Internally *C. clausa* may be distinguished from *C. elegantula* by the more abundant diaphragms in the zoœcial tubes, these being about twice as numerous in both the axial and peripheral regions. Vertical sections show that mesopores develop, as usual, with the inception of the peripheral region, but close before the surface is reached. The zoœcial walls are greatly thickened in the peripheral region by a dense deposit of tissue and in tangential sections the walls are seen to vary in thickness from one-half to two-thirds the diameter of the zoœcial tubes, although at the surface the walls appear quite thin, because here only their crest or summit is seen.

C. clausa is probably more closely related to *C. magnopora* than to the genotype, but the size of the zoarium and the tabulation of the zoœcia are so different that the two will hardly be confused. The zoarium of small, cylindrical, smooth branches, 3 to 4 mm. in diameter, the large, angular zoœcia, 4 to 5 in 2 mm., few mesopores, and internally the numerous diaphragms in both zoœcia and mesopores are the specific characters of this interesting form.

Occurrence.—Rather uncommon in the Rochester shale at Lockport and Rochester, N. Y., and Grimsby, Ontario. Several specimens were also obtained in the Osgood beds at Osgood, Ind.

Catalogue numbers, 44130, 35531, 35530, U. S. National Museum.

CALLOPORA MAGNOPORA Foerste.

Pl. XV, figs. 1-8; Pl. XXVI, fig. 3.

Callopora magnopora Foerste, Bull. Sci. Lab. Denison Univ., II, 1887, p. 173; III, pl. 16, fig. 5.
Callopora magnopora Foerste, Geol. Survey Ohio, VII, 1895, p. 600, pl. 29, fig. 5.

This species, which is not uncommon in the Clinton of Ohio, seems to be absent in the corresponding strata of New York, where, however, it reappears in the succeeding Rochester shale. Foerste's figures and description are inadequate, and the following description is based upon specimens received from that author.

Zoarium more or less irregularly ramose, the branches sometimes being subcylindrical and regularly dividing but often consisting of gnarled stems irregular in shape; diameter of branches varying from 5 to 12 mm. or more, but averaging 7 or 8 mm. Surface smooth, maculæ of larger zoœcia than those of the intermacular spaces, but not conspicuous.

[a] Ann. and Mag. Nat. Hist. (5), XIII, 1884, p. 120, pl. 7, figs. 4–4b.

Zoœcia larger than is usual in species of this genus, with subangular apertures and moderately thin walls, an average of 4 in 2 mm. Mesopores usually small and comparatively few at the surface, larger and more abundant at deeper zones in the zoarium. Opercula closing the zoœcia not observed at the surface, but detected in tangential sections.

Internal characters.—Tangential sections exhibit considerable variation in the size and shape of the zoœcia and the size and number of the mesopores. The reason for this is seen in vertical sections. Commencing with the mature region, more or less numerous mesopores are developed and these, as the surface of the zoarium is approached, are seen to become gradually smaller and less numerous and often pinched out altogether at the surface, the zoœcial diameter consequently becoming greater. A tangential section therefore passing through the early part of the peripheral region will show numerous mesopores and rounded zoœcia, while one taken just below the surface of the zoarium exhibits few and small mesopores and larger, angular zoœcia. In each case, however, because of this relation between the zoœcia and mesopores, the number of zoœcia in a given space is the same, even though they vary in diameter.

The surest guide for the identification of *C. magnopora* is the vertical section where the tabulation of the tubes is exhibited. All of the many specimens and sections examined indicate that the tabulation is the most constant feature of this as well as all the other species of the genus. The zoœcial tubes are closely tabulated at their inception, this tabulation continuing until the normal diameter of the zoœcia has been reached. Then diaphragms are absent altogether until the peripheral region is reached, and here they are uncommon, only one or rarely two being inserted in each tube.

The large zoarium and the peculiar tabulation of *C. magnopora* is so different from other species of the genus that comparisons are scarcely necessary. Vertical fractures when moistened and examined under a lens show the characteristic tabulation so well that sections are not a necessary adjunct for the identification of the species. The identification of the species in the Rochester shale is based upon a single example from Grimsby, Ontario. This specimen is a well-preserved subcylindrical branch 35 mm. in length and 10 mm. in diameter. The external characters are the same as in the typical Clinton specimens and, as our figures here given will show, the internal features of the two are identical.

Occurrence.—Abundant in the Clinton formation at Dayton, Centerville, and other localities in Ohio. Rare in the Rochester shale at Grimsby, Ontario.

Catalogue numbers, 35532, 44131, U. S. National Museum.

Family TREMATOPORIDÆ Ulrich.

Genus TREMATOPORA Hall.

Ulrich has shown in his "American Paleozoic Bryozoa" that of the numerous species referred to this genus by Hall only a few are congeneric with the common Rochester shale form, *T. tuberculosa*, the first species following the generic definition. The genus and species have been well defined by Ulrich in the work cited above, and the following description is but an adaptation from this author, the numerous specimens and thin sections showing no additional features.

Trematopora has many characters in common with the prolific Ordovician genus *Batostoma* and is probably the Silurian representative of the latter. The general internal structure of the two genera is similar, but the few diaphragms in the zoœcia, beaded mesopores, rounded zoœcia with more or less well-developed peristomes and comparatively small acanthopores, and the solid interspaces are characteristic of *Trematopora*.

TREMATOPORA TUBERCULOSA Hall.

Pl. XIII, figs. 15, 16; Pl. XVII, fig. 1 3; Pl. XXV, fig. 8.

Trematopora tuberculosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 149, pl. 40A, figs. 1a-g.
Trematopora tuberculosa Ulrich, Jour. Cincinnati Soc. Nat. Hist., VI, 1883, p. 259, pl. 13, figs. 2-2b.
Trematopora tuberculosa Grabau, Bull. New York State Mus., No. 45, 1901, p. 166, fig. 65.

Zoarium of irregularly ramose, solid, often flattened branches, an average specimen being 5 or 6 mm. wide and 3 or 4 mm. in thickness. Surface studded usually with low

rounded monticules, 3 to 3.5 mm. apart, measuring from center to center; sometimes, however, the maculæ are developed as sharp or elongate tubercules. Zoœcial apertures oval, 6 to 7 in 2 mm. measuring lengthwise, with more or less elevated peristomes, each bearing two or three rather large and conspicuous acanthopores. Interzoœcial spaces solid and somewhat depressed, the mesopores being closed at the surface by a pellicle-like covering. Mesopores few to numerous, the zoœcia sometimes being in contact but more often separated from each other by a distance varying from one-half to their entire diameter apart.

The fully matured region of most specimens is so short that good tangential sections are difficult to prepare. A section passing through the zoœcia just below the surface shows that they are oval and marked by rather thick ring-like walls within which acanthopores are developed. The mesopores are angular and thin walled, but often the section passes through the covering of the mesopores, in which case the walls are not visible, but the interzoœcial spaces are occupied by a fine tissue perforated by more or less numerous granular-like structures. In deep tangential sections the difference between zoœcia and mesopores is so small that they are distinguished with difficulty, each having thin walls and being about equal in size.

Vertical sections present the following characters: In the axial region the zoœcia are large with very thin walls and no diaphragms. With the inception of the peripheral region the walls are slightly thickened, and mesopores and acanthopores are developed, the diameter of the zoœcia being lessened by the introduction of the mesopores. The zoœcia in this region usually show no diaphragms, one or two rarely being developed in each tube, but the mesopores exhibit them in comparative abundance. The mesopores also give a beaded appearance, being constricted at intervals, diminishing from the interior toward the surface and each constriction being marked by a diaphragm. The last diaphragm has the minutely perforated laminated tissue developed upon it which closes the mesopores at the surface, but other diaphragms in the same tube are often thickened with the same tissue, although usually not to the extent obtaining at the surface.

The solid tuberculated branches with small zoœcia surrounded by peristomes bearing rather conspicuous acanthopores and with closed interspaces, make *Trematopora tuberculosa* an easily recognized species. The other species of the genus are so different that comparison is unnecessary. There is no associated bryozoan with which this species might be confused, save possibly *Eridotrypa nodulosa*, which has a similar growth and strongly tuberculated surface. The zoarium of the latter species, however, is smaller, the zoœcia have neither peristomes bearing acanthopores surrounding them nor solid interspaces, while internally the structure of the two is quite different.

Occurrence.—Very abundant in the Rochester shale at Lockport, Lewiston, Niagara Gorge, and elsewhere in New York and at Grimsby and Thorold, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue numbers, 43618, 35573, 35515, 44427, U. S. National Museum.

TREMATOPORA WHITFIELDI Ulrich.

Pl. XXIII, figs. 16, 17; Pl. XXVII, figs. 16, 17.

Trematopora whitfieldi Ulrich, Jour. Cincinnati Soc. Nat. Hist., VI, 1883, p. 262, pl. 13, figs. 4, 4a.

In the Waldron shales of Indiana may be found numerous specimens of a small ramose bryozoan, which has been described by Ulrich under the above name. A few examples identical in all respects with the western form occurred in the collections from the Rochester shale. Ulrich's original description covers the specific characters fully, and, with slight changes, is given below.

Zoarium slender, ramose, branches smooth, with an average diameter of 2.5 mm., and dividing dichotomously at intervals of 10 mm. more or less. True zoœcia subequal with elliptical apertures, surrounded by thin, more or less distinct peristomes, and uniformly arranged in diagonally intersecting series over the entire surface. In these 7 to 8 zoœcia

occupy the space of 2 mm. The longer diameter of their aperture is about 0.20 mm., while the shorter or transverse diameter averages about 0.15 mm. The interstitial cells are numerous, usually completely isolating the true zoœcia. Their apertures vary in depth in different specimens, being in some not readily distinguishable from the true zoœcial orifices and in others, on account of the interstitial membrane, scarcely detectable, being indicated only by shallow depressions between the peristomes of the true cells, which might be overlooked by a careless observer. Well-preserved examples show a number of small spiniform tubuli, whose position is usually on the peristomes.

Tangential sections show that the true zoœcia are elliptical in cross section, that their walls are slightly thickened by a secondary deposit on the inside, and that they are almost invariably completely isolated by a series of interstitial cells. These are angular, thin walled, and often larger than the true cells. A few spiniform tubuli may be detected, but not readily, on account of the many particles of pyrites of iron, which always obscure to a greater or less extent the minute internal characters of the bryozoa from the Waldron locality.

Longitudinal sections show that the true zoœcia are entirely without diaphragms. The peripheral region is very narrow, and, near the surface, always one and often two interstitial tubes separate the true zoœcia. The interstitial tubes are usually crossed by but a single diaphragm, which is placed about midway between their point of origin and the apertural covering. The tube is generally a little restricted where the diaphragm occurs.

This species differs from *T. tuberculosa* Hall in its much smaller, smooth, and cylindrical branches, which have altogether a more delicate appearance. Compared with *T. spiculata* Miller, it differs in its more elliptical and somewhat larger cell apertures and more distinct peristome.

Occurrence.—Quite abundant in the Waldron shales at Waldron and elsewhere in Indiana; less common in the Rochester shale at Lockport, N. Y., and Grimsby, Ontario.

Catalogue numbers, 44108, 35763, U. S. National Museum.

TREMATOPORA SPICULATA Miller.

Pl. XXVII, figs. 14, 15.

Trematopora spinulosa Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 11, figs. 11, 12. (Not *T. spinulosa* Hall, 1852.)

Trematopora spiculata Miller, American Pal. Foss., 2d ed., 1877, p. 245. (Proposed for *T. spinulosa*, preoccupied by Hall in 1852.)

Trematopora spiculata Hall, Twenty-eighth Ann. Rept. New York State Mus. (Museum ed.), 1879, p. 114, pl. 11, figs. 11, 12.

Trematopora spiculata Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882, p. 235, pl. 10, figs. 11, 12.

The study of the type specimen of this species now preserved in the collections of the American Museum of Natural History showed that it is an example of a form occurring rather abundantly in the Waldron shale of Indiana and less commonly in the Rochester shale of New York and Canada. The identity of this species was not suspected hitherto, because, as the type specimen shows, the enlarged view of the surface figured by Hall incorrectly represents this feature. The zoœcia, instead of being angular and contiguous, as represented in this figure, are in reality subovate and separated by a row of angular mesopores, which often attain a size equaling or exceeding the zoœcia themselves. The following description is believed to set forth the salient features of the species.

Zoarium of solid, ramose, frequently branching stems averaging 2 mm. in diameter. Zoœcia oval to circular, with a more or less well-developed peristome, thin walled, 0.17 mm. and 0.14 mm. in their longer and shorter diameters, respectively, 7 in 2 mm., measuring lengthwise. Interzoœcial spaces often as wide as the zoœcia and occupied by large, angular mesopores. Acanthopores small, but often so numerously developed as to occupy every angle, thus giving the spiculated surface.

Compared with *Trematopora whitfieldi* Ulrich, the only closely related associated species, the present form may be distinguished by its more circular and smaller zoœcia and relatively wider interapertural spaces. The acanthopores are also a more prominent surface feature and serve as an additional means of separating the two forms.

Occurrence.—Rather uncommon both in the Waldron shale at Waldron, Ind., and in the Rochester shale at Lockport, N. Y., and Grimsby, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35760, 35762, U. S. National Museum.

Genus MONOTRYPA Nicholson.

The massive zoarium consisting of simple, large, prismatic zoœcia, with thin, straight, or crinkled walls, usually few diaphragms, and no acanthopores or mesopores, is characteristic of this genus. The species described below represent two sections of the genus, one in which the zoœcia have crinkled walls and no diaphragms and the other with straight walls and diaphragms. However, as various species are intermediate in their characters between these extremes, this division of the genus is probably more an artificial than a natural one.

MONOTRYPA OSGOODENSIS n. sp.

Pl. XVI, figs. 1-5.

Compare *Astrocerium constrictum* Hall, Nat. Hist. New York, Pal. II, 1852, p. 123, pl. 34A, figs. 2a-c, 3a-c.

Zoarium massive, generally consisting of flat or hemispherical disks 10 to 20 mm. in diameter and 4 to 10 mm. high, but sometimes of larger rounded masses 20 to 30 mm. in thickness. Growth commences upon other organisms, but as it continues the zoarium becomes free and the base lined with a concentrically wrinkled epitheca. Celluliferous surface smooth, the zoœcia composing the maculæ being a trifle larger than the ordinary ones and on a plane with them. Zoœcial apertures thin walled, polygonal in outline, usually hexagonal, 4 to 5 in 2 mm. Acanthopores and mesopores wanting, the structures simulating the latter probably being young zoœcia.

Sections show that the walls are thin and straight, that the diaphragms are developed at intervals of from a tube diameter or more apart in the immature region to three in the same space in the mature zone. The immature and mature regions are very similar, but may be distinguished by the more numerous diaphragms and slight thickening of the walls in the latter region. Large zoaria often show successive immature and mature regions.

Specimens of this species are very similar externally to the associated *M. benjamini*, but a vertical fracture will show the differences, *M. osgoodensis* having straight walls and diaphragms and *M. benjamini* showing crinkled walls, no diaphragms, and slightly larger zoœcia. The zoœcia of *Orbignyella expansa* are also quite similar in size and shape, but the explanate growth and different internal structure will distinguish it. Hall has probably included this species with his *Astrocerium constrictum*, as some of his figures of the coral appear to represent this bryozoan. There should be no difficulty in separating the two, because of the thick walls and projecting septa of the coral.

Occurrence.—Abundant in the Osgood beds at Osgood, Ind., not uncommon in the Rochester shale at Lockport and Rochester, N. Y.

Catalogue numbers, 35498, 35499, 44118, U. S. National Museum.

MONOTRYPA BENJAMINI n. sp.

Pl. XVI, figs. 6-9; Pl. XXVI, fig. 11.

Zoarium of globular or subglobular masses a centimeter or more in diameter. Surface smooth, maculæ not conspicuous. Zoœcia angular, thin walled, usually 4 in 2 mm.; diaphragms wanting. Zoœcial walls finely crenulated, 15 or more wrinkles in 2 mm.

This species is congeneric and, indeed, very closely related to the genotype of Hall's genus *Ptychonema*, *P. tabulatus* from the Lower Devonian of New York. Judging from the description and figures, Hall's species forms larger zoaria, has slightly larger zoœcia, and more widely separated corrugations than the form here described. The genus *Ptychonema* was established for species having slightly corrugated walls and no diaphragms. As the genotype of *Monotrypa* has crinkled walls and few diaphragms and other species of the

genus exhibit no diaphragms at all and straight walls, the combination of crinkled walls and absence of diaphragms seems a poor generic character. *Ptychonema* is therefore considered a synonym.

The only associated globular species with which *M. benjamini* might be confused is *Stigmatella globata*, but the much smaller zoœcia of the latter are noticeable with the unaided eye. Some specimens of *Orbignyella expansa* might be confused with this form, but the presence of curved diaphragms in the former is a distinguishing feature without considering the different growth and wall structure. *M. benjamini* is easily and certainly identified by observing the crenulated walls as seen in vertical fractures. Weller [a] has recently described a closely related species, *M. corrugata*, from the Decker Ferry formation of New Jersey. This species, however, has smaller zoœcia (10 in 3.5 mm.), a few diaphragms in the mature region, and the crenulation of the walls are fewer and much less pronounced.

The specific name is in honor of Dr. Marcus Benjamin, editor of the United States National Museum, to whom the writer is indebted for many courtesies.

Occurrence.—Not uncommon at Lockport, N. Y. One example of the same form was found at Osgood, Ind.

Catalogue numbers, 35500, 44129, U. S. National Museum.

Monotrypa pediculata n. sp.

Pl. XVI, figs. 10-13.

Zoarium of small subglobular or pear-shaped pedunculate masses averaging 10 mm. in height and half that amount in width; base often slightly expanded. Surface smooth, maculæ inconspicuous. Zoœcia angular, thin walled, 6 to 7 in 2 mm. Acanthopores and mesopores wanting. Vertical sections show that the zoœcial tubes have somewhat flexuous walls and that diaphragms are absent. The walls, however, do not exhibit the crinkling usually observed in species without diaphragms.

The unusual growth obtaining in this species is a character making identification comparatively easy. The initial zoœcia are parasitic upon foreign objects and continue to grow upward, opening only at the top. In this way the pedunculate form of the zoarium is produced, the lower portion of the colony being without apertures and covered with an epitheca or pellicular membrane. When new zoœcia are interpolated the zoarium assumes the normal globular form with the zoœcia opening laterally as well as distally. Compared further with the associated species of the genus, *M. pediculata* differs from both in having smaller zoœcia. Other distinguishing characters are the absence of diaphragms and the flexuous walls.

Occurrence.—Rochester shale, Rochester, N. Y. Osgood beds, Osgood, and near Waldron, Ind.

Catalogue numbers, 44119, 44120, U. S. National Museum.

Genus DIPLOTRYPA Nicholson.

Distinguished from *Monotrypa* by the presence of mesopores.

Diplotrypa walkeri n. sp.

Pl. XIV, figs. 1-5; Pl. XXV, fig. 4.

Zoarium of small masses, irregular, rounded, or pyriform in shape and varying from 10 to 20 mm. in their diameter. Maculæ of larger zoœcia and more numerous mesopores are present, but are not a conspicuous feature of the smooth surface. Zoœcia, 6 in 2 mm., sometimes angular but more often somewhat rounded and separated, at least partially, by mesopores. Acanthopores wanting. Mesopores numerous, usually small but sometimes half as large as the zoœcia proper.

[a] Geol. Survey New Jersey, Pal. III, 1903, p. 223, pl. 18, figs. 1-5.

Vertical sections are particularly instructive and bring out the generic characters. Diaphragms are wanting in the immature region of the zoœcial tubes and few are found in the mature zone. Indeed, in a zoarium built up of several successive immature and mature regions the latter region is recognized chiefly by the presence of diaphragms. In the mesopores the diaphragms are at intervals varying from one-half to an entire diameter apart. The mesopores also exhibit a feature that has been noticed in other species of the genus, namely that at about the same height in the zoarium a number of mesopores with their close tabulation will cease as such and their places be taken by the untabulated zoœcial tubes. The tabulation and size of the zoœcia in this species are so different from those of other species of the genus that comparison is not necessary. Associated species with a similar zoarium are the various species of *Monotrypa*, but the absence of mesopores in these forms will easily distinguish them under a lens.

This species is named in honor of Mr. B. E. Walker, of Toronto, Canada, in appreciation of his keen interest in paleontology and his generous help in loaning many fine specimens.

Occurrence.—Not uncommon at Grimsby, Ontario, and at Lockport and Rochester, N. Y.

Catalogue number, 35527, U. S. National Museum.

Order CRYPTOSTOMATA Vine.

Representatives of eighteen genera distributed among eight families of this order are found in the Rochester shale, making the Cryptostomata the best represented group, generically at least. Cryptostomatous bryozoa are characterized by the primary zoœcial orifice being produced into a tubular shaft—the vestibule.

Family PHYLLOPORINIDÆ Ulrich.

Genus PHYLLOPORINA Ulrich.

This genus comprises characters pertaining to several orders, and is one of the "comprehensive" types that occur occasionally in Paleozoic strata. The zoarium is of irregularly anastomosing branches, with two to eight rows of apertures on the obverse side, the reverse longitudinally striated; tabulated interstitial spaces closed at the surface; acanthopores generally present.

PHYLLOPORINA ASPERATO-STRIATA (Hall).

Pl. XVIII, figs. 1-5.

Reteporn asperato-striata Hall, Nat. Hist. New York, Pal. II, 1852, p. 161, pl. 40C, figs. 2a–h.
Subretepora asperato-striata Miller, North American Geol. and Pal., 1889, p. 326.
Phylloporina asperato-striata Ulrich, Geol Survey Illinois, VIII, 1890, p. 332, pl. 53, figs. 5–5b
Phylloporina asperato-striata Grabau, Bull. New York State Mus., No. 45, 1901, p. 168, fig. 68.

Zoarium of rather regularly inosculating branches arising from a slightly expanded base and forming a reticulate, flat, undulating or broadly funnel-shaped expansion, sometimes reaching a diameter of 70 or 80 mm. Branches varying from 0.8 to 1 mm. in width, but usually the different parts of the same specimen are uniform in this respect. Fenestrules rather regular in shape, oval to subelliptical, but somewhat variable in size, the average being about 1.10 mm. in length and 0.45 mm. in width. Measuring longitudinally 9 to 10 fenestrules may be counted in 20 mm., while transversely 15 occupy the same space. The celluliferous side exhibits 4 to 6 ranges of zoœcia. Apertures circular or subpolygonal, closely crowded together, 6 to 7 in 2 mm. In well-preserved examples the longitudinal striæ of the reverse side are seen under a magnifier to be minutely denticulate, thus suggesting the specific name.

Both the external and internal characters of this well-marked species have been figured, the former by Hall and the latter by Ulrich. The large anastomosing branches with four to six rows of polygonal zoœcia are readily recognized.

Occurrence.—Abundant at Lockport, Rochester, Niagara Falls, and other localities where the Rochester shale outcrops in western New York, and at Grimsby, Thorold, and Hamilton, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue number, 35740, 35741, 43441, U. S. National Museum.

Genus PSEUDOHORNERA Roemer.

Pseudohornera Roemer, Leth. geog., Leth. Pal., I, Atlas, 1876, expl. pl. 12.
Drymotrypa Ulrich, Geol. Survey Illinois, VIII, 1890, p. 399.
Drymotrypa Miller, North American Geol. and Pal., First App., 1892, p. 684.
Thamnocella Simpson, Fourteenth Ann. Rept. State Geol. New York for 1895, 1897, p. 525.
Drymotrypa Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 235.

It is unfortunate that the well-defined genus *Drymotrypa* must be abandoned in favor of the name *Pseudohornera*, which not only lacks description but also expresses a false relationship; but as both genera were founded upon the same species, Hall's *Retepora diffusa*, there is no doubt of their identity. In the explanation of Pl. 12, figs. 2a, 2b, of the work cited, Roemer gives the new name *Pseudohornera diffusa* to Hall's species and illustrates the genus by copies of Hall's figures, intending, no doubt, to define the genus in the text, which, however, never appeared. The rules of nomenclature require recognition of generic names founded upon well-illustrated species, and, as *Pseudohornera* meets with this requirement, the name is here used in place of *Drymotrypa*. The writer may be accused of inconsistency in recognizing *Pseudohornera* in place of *Drymotrypa* and then accepting *Phylloporina* instead of the much earlier name *Subretepora*, both of which were founded upon the same type of structure, but the two are not parallel cases. *Pseudohornera* is founded upon good figures correctly illustrating the type species while D'Orbigny's *Subretepora* was proposed for *Intricaria clathrata* Hall, which was both figured and described incorrectly.

The writer is indebted to Miss Margaret W. Moodey, of the United States National Museum, for calling attention to *Pseudohornera*, as well as for many other valuable bibliographic references which she has discovered during the preparation of a catalogue of North American invertebrate fossils.

The zoarium in *Pseudohornera* is of dichotomously dividing branches, celluliferous on one side and longitudinally striated on the reverse. The zoœcia are in several ranges and spring from a thin double plate, beneath which is a number of vesicles; the vestibules expand from the orifice to the angular apertures.

PSEUDOHORNERA NIAGARENSIS (Hall).

Pl. XVIII, fig. 20; Pl. XIX, figs. 14–16.

Fenestella n. sp. Hall, Nat. Hist. New York, Pal. II, 1852, pl. 40D, fig. 4.
Thamniscus ? Niagarensis Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 11, figs. 22–25; Ibid. (Mus. ed.), 1879, p. 126, pl. 11, figs. 22–25.
Thamniscus niagarensis Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882, p. 254, pl. 10, figs. 22–25.
Drymotrypa niagarensis Ulrich, Geol. Survey Illinois, VIII, 1890, p. 399.
Thamniscus Niagarensis Simpson, Fourteenth Ann. Rept. State Geol. New York, for the year 1894, 1897, pl. 9, figs. 15–17.

The collections from the Rochester shale contain several well-preserved specimens of this species, which was described from the Waldron beds at Waldron, Ind., and hitherto has not been recorded from any other horizon or locality. The Waldron specimens show a slight variation in the shape of the celluliferous side, this being either angular along a central line, or rounded. The specimens from New York exhibit only an angulated obverse. This angulation is a good specific character, the rounded obverse being only a feature of the aged condition. Compared with *P. diffusa*, this species, in addition to having the character just mentioned, is distinguished by having the reverse marked with 3 to 5 granulose striæ, instead of 6 to 8, in the width of a branch, and by an obverse side with 3 to 4 ranges of more rounded zoœcia. *P. niagarensis* has not the graceful method of growth pertaining to *D. diffusa* and is a less handsome species in every respect.

The specimen figured by Hall as *Fenestella* (n. sp.) on Pl. 40D, fig. 4, of Nat. Hist. New York, Pal. II, proves to belong to this species.

Occurrence.—Not uncommon in the Rochester shale at Lockport and Niagara Falls, N. Y., and in the Waldron shale at Waldron, Ind.

Catalogue number, 35742, U. S. National Museum.

PSEUDOHORNERA DIFFUSA (Hall).

Pl. XVIII, figs. 6-9; Pl. XXIII, figs. 1-3.

Retepora diffusa Hall, Nat. Hist. New York, Pal. II, 1852, p. 160, pl. 40C.
Pseudohornera diffusa Roemer, Leth. geog., Leth. Pal., I, Atlas, 1876, pl. 12, fig. 2.
Drymotrypa diffusa Ulrich, Geol. Survey Illinois, VIII, 1890, p. 399, pl. 53, fig. 7, 7b.
Drymotrypa diffusa Grabau, Bull. New York State Mus., No. 45, 1901, p. 169, fig. 69.
Compare *Polypora ? problematica* Vine, Quart. Jour. Geol. Soc. London, XXXVIII, 1882, p. 62.

This, the genotype, has been fully figured and described by Hall and Ulrich, and the following description is inserted mainly for the sake of completeness.

Zoarium, a loosely spreading frond growing in a plane and consisting of branches about 1.5 mm. in diameter, dividing dichotomously at short intervals; an entire zoarium about 50 mm. in both height and width. Celluliferous side bearing from 4 to 6 rows of zoœcia, springing from a thin double lamina, 5 zoœcia in 2 mm. measuring lengthwise. Noncelluliferous side marked by 6 to 8 longitudinal striæ.

This beautiful form is readily recognized by its dichotomously dividing, nonanastomosing branches, the longitudinally striated reverse and the smooth, slightly rounded obverse bearing 4 to 6 ranges of zoœcia. The associated species, *P. niagarensis*, has a similar method of growth, but may easily be distinguished by its usually angular obverse, bearing circular apertures, and fewer ranges of zoœcia.

The collections of the U. S. National Museum contain specimens of *Polypora? problematica* Vine, identified by the author of that species, which are closely related if not identical with Hall's species. At any rate, *Polypora ? problematica* is the European representative of *Pseudohornera diffusa*.

Occurrence.—Rather uncommon in the Rochester shale at Lockport and Rochester, N. Y., and at Grimsby, Ontario.

Catalogue number, 43389, U. S. National Museum.

Family FENESTELLIDÆ King.

Genus FENESTELLA Lonsdale.

Zoarium flabellate or funnel shaped, celluliferous on the inner side; branches generally straight, sometimes flexuous, connected at regular intervals by dissepiments; apertures in two rows, separated by a plain or tuberculated keel.

FENESTELLA CRIBROSA Hall.

Pl. XIX, figs. 3-5.

Fenestella cribrosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 166, pl. 40D, figs. 3a, b.

Original description.—Frond expanded or cyathiform; branches strong, irregularly bifurcating; surface striated; transverse bars or dissepiments thin, scarcely enlarging at their junction with the branches; fenestrules small, quadrangular, sometimes oval; poriferous side unknown.

Fenestrules eleven in the space of three lines longitudinally, and eighteen in the same space transversely.

This species is readily distinguished by the small angular fenestrules, which are much more numerous than in the same space in any other species in this group; the branches are quite as strong, or even stronger than in *F. elegans*. It is easily distinguished, therefore, by the noncelluliferous side alone.

The specimen in the collections of the American Museum of Natural History, marked as the type of this species, does not agree with either Hall's description or figures, but appears to be an example of *Polypora incepta*. In the Rochester shale at the localities mentioned below, several examples of a neat little *Fenestella* have been found which agree in all essential respects with Hall's description and figures. Under these circumstances the writer believes that the specimen now designated as the type of the species has been inadvertently marked as such, and that the original type, which possibly has been lost, was an example of the form figured on Pl. XIX as *F. cribrosa*.

F. cribrosa may readily be distinguished from associated fenestellids by the small size and quadrangular shape of the fenestrules, the wide branches, and striated noncelluliferous side. On the celluliferous face the characters to be noted are the occurrence of protruding zoœcial apertures generally two but sometimes three to a fenestrule. The carina is moderately elevated but conspicuous spines are developed, averaging two to a fenestrule.

Occurrence.—Rather rare at Lockport; not uncommon at Middleport, N. Y.

Catalogue number, 35553, U. S. National Museum.

FENESTELLA ELEGANS Hall.

Pl. XIX, figs. 1, 2.

Fenestella elegans Hall, Nat. Hist. New York, Pal. II, 1852, p. 164, pl. 40D, figs. 1a-g.
Fenestella elegans Grabau, Bull. New York State Mus., No. 45, 1901, p. 170, fig. 70.

The characters of this as well as most of the other Rochester shale fenestellids have been well illustrated by Hall, and the following brief description and measurements are given for completeness:

Fenestrules quadrangular, 3 to 4 in 3 mm., measuring longitudinally, and 6 in 3 mm. transversely. Zoœcia in two ranges separated by a sharp, moderately elevated carina, which in perfect specimens bears small spines at intervals of about 0.4 mm.; 4 zoœcia to a fenestrule. On the reverse side the fenestrules are quadrangular and two or three fine striations mark the branches.

Occurrence.—Fragments are common at Lockport, the type locality, and at all the other localities in western New York; good specimens occur also at Thorold, Hamilton, and Grimsby, Ontario.

Catalogue number, 44143, U. S. National Museum.

Genus PTILOPORELLA Hall.

Like *Fenestella*, except that at regular intervals the branches are considerably thickened and form rib-like supports.

PTILOPORELLA NERVATA (Nicholson).

Pl. XXIV, figs. 24, 25; Pl. XXVI, figs. 5, 6.

Fenestella nervata Nicholson, Pal. Ohio, II, 1875, p. 264, pl. 25, figs. 11, 11a.
Ptiloporella nervata Miller, North American Geol. and Pal., 1889, p. 319.

Several large examples and numerous fragments of this species were found at Grimsby, Ontario, and at Lockport, N. Y., one of them collected by Mr. Ulrich showing a spread of 160 mm. The rib-like development of the branches at regular intervals will cause the recognition of the form to be easy. The measurements of the Rochester shale specimens agree in all essential respects with the Ohio types as figured by Nicholson, so that there seems to be no question of their specific identity. For convenience of reference, Nicholson's figures are reproduced on Pl. XXIV.

Occurrence.—Rochester shale, Lockport, N. Y., and Grimsby, Thorold, and Hamilton, Ontario; Osgood beds, Osgood, Ind. Nicholson's types were found in the Niagara limestone at Cedarville, Ohio.

Catalogue numbers, 35743, 44144, U. S. National Museum.

Genus SEMICOSCINIUM Prout.

Zoarium as in *Fenestella* save that the zoœcia are developed on the outer side of the branches and that the keel has a much expanded summit.

SEMICOSCINIUM TENUICEPS (Hall).

Pl. XIX, figs. 6, 7.

Fenestella tenuiceps Hall, Nat. Hist. New York, Pal. II, 1852, p. 165, pl. 40D, figs. 2a-b.
Semicoscinium tenuiceps Ulrich, Geol. Survey Illinois, VIII, 1890, p. 355.
Semicoscinium tenuiceps Grabau, Bull. New York State Mus., No. 45, 1901, p. 171, fig. 72.

Hall's figures bring out the characters of this species so well that there is no difficulty in distinguishing it from the associated fenestellids. The sharp, prominent carina, the essential feature of the genus, is somewhat flexuous or undulating toward the base of the zoarium but straighter in the upper portions. Three to 4 fenestrules may be measured in 3 mm. longitudinally, and 4 to 6 in the same space transversely; 4 to 5 zoœcia to a fenestrule. In the typical forms of *Semicoscinium*, the fenestrules on the inner or reverse side are subrhomboidal or rounded, but in this and other early species the fenestrules are much as in *Fenestella*, thus showing the origin of the genus.

Occurrence.—Abundant at Lockport, Rochester, Lewiston, and Niagara Falls, N. Y.; Grimsby, Ontario. Rare in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35744, 35745, 35746, U. S. National Museum.

Genus POLYPORA McCoy.

Zoarium as in *Fenestella*, but the median keel is absent and two to eight rows of zoœcia are present on a branch.

POLYPORA INCEPTA Hall.

Pl. XIX, figs. 8-13.

Polypora incepta Hall, Nat. Hist. New York, Pal. II, 1852, p. 167, pl. 40D, figs. 5a-f.
Polypora incepta Ulrich, Geol. Survey Illinois, VIII, 1890, p. 358, pl. 55, fig. 1.
Polypora incepta Grabau, Bull. New York State Mus., No. 45, 1901, p. 172, fig. 73.

This pretty form was adequately figured by Hall and is easily distinguished from associated fenestellids by its more robust habit of growth and the additional ranges of zoœcia. The specific characters are as follows: Zoœcia in three or four ranges; apertures oval, alternating, branches dividing regularly; dissepiments slender, little enlarged at their junction with the branches. Fenestrules oblong, quadrangular, 4 to 4.5 in 6 mm., measuring longitudinally, and 7 to 10 in the same space transversely. Reverse side of branches longitudinally striated.

Occurrence.—Not uncommon at Rochester and Lockport N. Y., and Grimsby, Ontario.

Catalogue numbers, 35747, 35748, 44145, U. S. National Museum.

Genus LOCULIPORA Hall.

The zoarium in this genus resembles *Fenestella* except that the dissepiments are short, typically reduced to a minimum, and that the branches and dissepiments are carinated, the carinæ coalescing and their summits much expanded, causing the obverse and reverse sides to have much the same appearance.

Loculipora was founded upon a Hamilton species, *Fenestella perforata* Hall, in which the branches approach so closely together that the zoœcial apertures appear to occupy the dissepiments as well as the branches. Thin sections, however, show that the dissepiments are, as usual, nonporiferous, but are reduced in length to such an extent that the branches are brought almost into contact. In the species discussed below, for which type of structure the generic term *Tectulipora* was proposed by Hall, the dissepiments, although more pronounced, still exhibit considerable variation in this respect and show their relation to the more typical forms of *Loculipora*. *Tectulipora*, therefore, could be distinguished from *Loculipora* only by the better development of the solid portions of the dissepiments, but at present this feature can not be considered as a good generic character.

LOCULIPORA ULRICHI n. sp.

Pl. XXI, fig. 2; Pl. XXV, figs. 22–24.

Compared with the Waldron species, *L. ambigua* Hall, this new form presents the following differences. First, the form of the zoarium, especially the basal portion, differs in that it is much narrower, is stalk-like, and expands much more slowly; second, the reverse side of the zoarium is less distinctly papillated; third, the obverse side is more regularly and constantly striated; fourth, the fenestrules on the obverse (outer) side are more regular and quadrate in form; fifth, the apertural rim of the zoœcia is less developed; and sixth, the zoarium as a whole is a trifle less robust. The stalk-like form of the zoarium, the regularly striated obverse side, and the quadrate form of the fenestrules are the most obvious features and will readily prevent confusion with related species.

Tangential sections of *L. ulrichi* show that the apertural rim is so little developed that it is scarcely distinguishable, but in similar sections of *L. ambigua* the rim is a very conspicuous feature. Compared further *L. ulrichi* has smaller fenestrules, 8 occurring in 5 mm., measuring lengthwise, and 10 in the same space transversely, while in *L. ambigua* 6 and 9 occur respectively in the same spaces.

The other Silurian species, *L. gothlandica* Ulrich, from the island of Gotland, is also related, but differs in that its fenestrules are smaller and less quadrate and the zoarium expands more rapidly.

This fine species is named in honor of Dr. E. O. Ulrich of the U. S. Geological Survey, to whom the writer is indebted for valued suggestions and help in the preparation of this paper.

Occurrence.—Lockport, Lewiston, Niagara Gorge, and Rochester, N. Y.; Grimsby and Thorold, Ontario.

Catalogue numbers, 35548, 35765, 35766, U. S. National Museum.

LOCULIPORA AMBIGUA var. PRECURSOR n. var.

Compare *Loculipora ambigua* (Hall), Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), 1876, pl. 11, figs. 17-21; (Mus. ed.) 1879, p. 123, pl. 11, figs. 17-21; Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882, p. 248, pl. 11, figs. 17-21.

This subordinate name is proposed to distinguish a form of *Loculipora* found rather rarely in the Rochester shale at Lockport, and in the corresponding Osgood beds at Osgood, Ind. All of the specimens so far seen agree with *L. ambigua* in size and in having an obtusely conical zoarium with comparatively irregular branches and fenestrules. The reverse side of the branches is granulo-striate, agreeing in this respect with young specimens of *L. ambigua*, but the zoœcial apertures of the proposed variety are scarcely so much elevated as in the typical form of the species. Better material perhaps might show reasons for considering this a distinct species, but at present it seems best to consider it only an early variety of the Waldron form.

Occurrence.—Apparently rare in the Rochester shale at Lockport, N. Y., and in the Osgood beds at Osgood, Ind.

Catalogue numbers, 35554, 35555, U. S. National Museum.

Genus THAMNISCUS King.

Zoarium as in *Polypora*, but branches bifurcate more frequently and are rarely or not at all connected by dissepiments.

THAMNISCUS DICHOTOMUS (Hall).

Pl. XVIII, figs. 17-19; pl. XXVII, figs. 1-7.

Hornera ? dichotoma Hall, Nat. Hist. New York, Pal. II, 1852, p. 163, pl. 40 C, fig. 3d (not figs. 3a, b).
Subretepora dichotoma Miller, North American Geol. and Pal., 1889, p. 326.
Thamniscus dichotomus Ulrich, Geol. Survey Illinois, VIII, 1890, p. 607.
Stictopora dichotoma Whitfield and Hovey, Bull. Am. Mus. Nat. Hist., XI, pt. 2, 1899, p. 108.

At most localities showing the Rochester shale, abundant specimens of an undoubted and well-marked species of *Thamniscus* may be found which has been regarded as identical with *Hornera ? dichotoma* Hall. In their catalogue of type specimens in the American Museum of Natural History[a], Whitfield and Hovey referred this species to *Stictopora* with the remark that the specimen of *Hornera ? dichotoma* which bears Professor Hall's original ticket and references to the figures (Nat. Hist. New York, Pal. II, 1852, pl. 40C, figs. 3a, 3b) is not like either description or figures, but is elliptical in section and poriferous on both sides. Through the courtesy of Professor Whitfield the writer has been able to examine the type specimen referred to and finds it to be a narrow but otherwise normal example of the common *Pachydictya crassa* (Hall). Hall's figures, 3a and 3b, are poor and differ in several respects from the type specimen, so that it is a question whether this example is really the original. They might equally well represent a branch of the abundant *Thamniscus*. Under these circumstances it seems best to disregard these two figures and base the species upon the third figure, 3d, and Hall's description, instead of considering *Hornera ? dichotoma* as synonymous with *Pachydictya crassa*. As the original description quoted below and the figure on Pl. XXVII show, *Hornera ? dichotoma* is an easily distinguished form of *Thamniscus*, differing from other American forms by its extremely regular, dichotomously branching method of growth.

Original description.—Stems minute, semicylindrical, rigidly branching or bifurcating; one surface striated longitudinally, the other celluliferous; cells with round or oval apertures, which open from the summit of a pustuliform elevation.

This species is extremely minute, its characters being scarcely distinguishable with the naked eye. In its striated and poriferous surface it resembles in general characters *Retepora;* but the mode of branching is different, and the cells are round or oval, with the openings elevated above the surface of the branch, which does not occur in *Retepora*.

The following description is believed to contain the essential characters of the species:

Zoarium of small, slender, dichotomously dividing branches generally 0.4 or 0.5 mm. in breadth but increasing to 0.6 or 0.7 mm. before a bifurcation. Branching regular, occurring at intervals of 5 to 7 mm.; angle of bifurcation small, generally less than 30°. Branches flat on the reverse, slightly convex on the obverse or celluliferous side. Zoœcia usually arranged in three or four ranges, but just before a bifurcation the number may be increased to five or six. Zoœcial apertures circular or oval, 0.10 to 0.12 mm. in diameter opening from the summits of small pustuliform elevations, 8 in 2 mm. measured longitudinally. In young specimens the zoœcia are arranged in well-marked longitudinal series separated by a low ridge, the zoœcial spaces are faintly marked with small nodes, and the elevations from which the apertures open are pronounced. In old examples the separating ridges and zoœcial elevations are less pronounced while the apertural walls bear numerous nodes which often indent the zoœcial cavity. The noncelluliferous side is longitudinally striated, the lines as shown on well-preserved specimens being composed of small nodes or granules.

The regular, dichotomously branching method of growth, the flat, striated, noncelluliferous face, and the slightly convex obverse side with small rounded zoœcia are characters which readily distinguish *Thamniscus dichotomus* from all associated bryozoa.

Occurrence.—Lockport, Rochester, and other localities in western New York; Grimsby and Hamilton, Ontario.

Catalogue numbers, 35558, 35751, 44147, U. S. National Museum.

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[a] Bull. Am. Mus. Nat. Hist., XI, pt. 2, 1899, p. 108.

Family PTILODICTYONIDÆ Ulrich.

Genus PHÆNOPORA Hall.

Distinguished from *Ptilodictya* by the presence of two or more mesopores in each interspace between the ends of the apertures.

PHÆNOPORA ENSIFORMIS Hall.

Pl. XXVII, figs. 8, 9.

Phænopora ensiformis Hall, Nat. Hist. New York, Pal. II, 1852, p. 48, pl. 18, figs. 8a-c.
Phænopora ensiformis Nicholson and Hinde, Canadian Journal, new ser., XIV, 1874, p. 142.
Phænopora ensiformis Nicholson, Pal. Province Ontario, 1875, p. 45, figs. 19, 2, 2a.
Ptilodictya ensiformis Ulrich, Jour. Cincinnati Soc. Nat. Hist., V, 1882, p. 172.
Phænopora ensiformis Foerste, Geol. Survey, Ohio, VII, 1895, p. 598.

A narrow, unbranched species of *Phænopora* occurs not uncommonly at most of the Rochester shale localities and agrees in all respects with the Clinton form described by Hall as *Phænopora ensiformis*. In this form the characteristic mesopores occupying the interspaces between the ends of the aperture are often made out with difficulty and this fact causes the zoarium to resemble *Ptilodictya* very closely. Upon close examination, however, or by means of thin sections, two small mesopores may be found occupying the position normal for *Phænopora*.

The zoarium, which is bifoliate and pointed at the base for articulation, averages 25 mm. in length and 2 mm. in width; each face bears from 7 to 11 parallel rows of zoœcia; 6 zoœcia in 2 mm. measured longitudinally; apertures in linear series between slightly raised longitudinal lines, quadrangular, measuring about 0.18 mm. by 0.30 mm., but in marginal series, oval slightly oblique and larger than in the middle ranges.

Occurrence.—Abundant in the Clinton rocks of western New York and Ontario, and not uncommon in the Rochester shale of the same region. Rare in the Clinton rocks of Ohio and also in the Osgood beds at Osgood, Ind.

Catalogue number, 35752, U. S. National Museum.

PHÆNOPORA FIMBRIATA var. CANADENSIS n. var.

Pl. XXI, figs. 17-19.

Compare *Phænopora fimbriata* (James) Foerste, Bull. Sci. Lab. Denison Univ., II, 1887, p. 161; ibid., III, 1888, pl. 15, fig. 7.

The form for which the above varietal name is proposed agrees in method of growth with the characteristic Ohio Clinton species *Phænopora fimbriata*, but differs in the following respects. First the zoœcia of the variety are smaller, 8 occurring in 2 mm., measuring lengthwise, while only 6 are found in the same space in the Clinton form. Second, the walls of the variety are considerably thinner while the mesopores are small and inconspicuous. While the thin walls and small, inconspicuous mesopores of the variety may be due to a youthful stage of growth in the specimens studied, yet the smaller zoœcia seem to be of sufficient importance to designate the Rochester shale form as a good variety if not a species.

Occurrence.—Rochester shale, Lockport, N. Y., and Grimsby, Ontario.

Catalogue numbers, 35753, 44148, U. S. National Museum.

Genus CLATHROPORA Hall.

Like *Ptilodictya* save that the zoarium consists of branches anastomosing so as to form a regular network with round or oval fenestrules.

CLATHROPORA FRONDOSA Hall.

Pl. XX, figs. 5-11; Pl. XXI, figs. 6, 7.

Clathropora frondosa Hall, Nat. Hist. New York, Pal. II, 1852, p. 160, pl. 40B, figs. 5 a-c.
Clathropora frondosa Grabau, Bull. New York State Mus. No. 45, 1901, p. 174, fig. 75.

Zoarium large, frondescent, consisting of anastomosing branches forming a network which in old examples is often 10 cm. or more in length and width. Proximal portion marked with finer longitudinal striæ, long and pointed in young examples, but with age becoming so thickened as to be wedge shaped. This part of the zoarium articulates into a cup-shaped depression of a spreading base attached to foreign objects. The older the zoarium the more thickened is the proximal portion, and here the branches sometimes become so broad that the fenestrulés are obliterated. Branches elliptical in cross section 1.5 to 3 mm. in breadth and carrying on each side from 8 to 15 or even more ranges of zoœcia arranged in linear series. Fenestrules oval, 1.2 by 2 mm. being an average dimension although, because of age and position, considerable variation is found; about 2.5 or 3 in 10 mm., measuring longitudinally, and the same number in 8 or 9 mm. diagonally. Zoœcial apertures rhomboidal, oblong-quadrangular, or elongate-hexagonal, the shape varying in different portions of the zoarium, 8 to 9 in 2 mm. longitudinally and 11 in the same space measured transversely.

There is no associated species save the variety mentioned below with which this might be confounded. A large complete example with its network of branches, oval fenestrules and pointed base forms an exceedingly handsome cabinet specimen.

Occurrence.—Fragments are common, but complete specimens are more rarely found. Lockport, N. Y., Thorold, Hamilton, and Grimsby, Ontario.

Catalogue numbers, 44146, 44147, U. S. National Museum.

CLATHROPORA FRONDOSA INTERMEDIA Nicholson and Hinde.

Clathropora intermedia Nicholson and Hinde, Canadian Journal, new ser., XIV, 1874, p. 140, fig. 5.
Clathropora intermedia Nicholson, Pal. Province Ontario, 1875, p. 59, fig. 29 a, b.

Original description. *Clathropora intermedia* Nich. and Hinde. Perforations moderately large, from two-thirds to one line in diameter, placed at intervals of rather more than half a line, six or seven rows of cells in half line, and seven or eight rows between any two perforations.
Niagara limestone, Thorold, Ontario.

The authors of this form distinguished it from *Clathropora frondosa* mainly on account of the possession of larger fenestrules. As shown under the above description, the size of the fenestrules is a variable character. The only additional character found by the writer to distinguish the two forms is that the zoœcia of *C. intermedia* are slightly larger than those of Hall's species; the former having 7 in 2 mm. longitudinally, and 9 to 10 in the same space transversely, while the latter, as stated above, has 8 and 11 in the corresponding measurements. The two distinctive characters mentioned are so slight that *C. intermedia* can hardly be regarded as more than a variety of *C. frondosa*.

Occurrence.—Rochester shale, Thorold and Hamilton, Ontario.

Catalogue numbers, 35749, 35750, U. S. National Museum.

CLATHROPORA ALCICORNIS Hall.

Pl. XX, figs. 1-4.

Clathropora alcicornis Hall, Nat. Hist. New York, Pal. II, 1852, p. 159, pl. 40B, figs. 4 a-c.
Clathropora alcicornis Grabau, Bull. New York State Mus., No. 45, 1901, p. 174, fig. 76.

This form is easily recognized from the figures given by Hall and is distinguished from all other species of the genus by the failure of the branches to form a network with oval fenestrules as in the typical species. Otherwise the structure is as required for the genus, as the

thin section prepared from the type specimen, figured on Pl. XX, indicates. The zoœcia are large, 5 to 6 in 2 mm., measuring longitudinally and about 10 in the same space transversely.

Occurrence.—Rare in the shales at Lockport, N. Y.

Family STICTOPORELLIDÆ Nicklas and Bassler.

Genus TÆNIODICTYA Ulrich.

Zoarium growing from a basal expansion into narrow, dichotomously divided branches or broad fronds; zoœcial structure much as in *Ptilodictya*. The species described below, although the earliest known, appears to possess all the essential generic characters.

TÆNIODICTYA SCHUCHERTI n. sp.

Pl. XXVII, figs. 10–13.

Zoarium, as observed from the only specimen found, of flexuous, parallel-edged branches, 3 mm. in width, dividing dichotomously at intervals of from 6 to 9 mm. Zoœcial apertures rather large for the genus, 4 in 2 mm., measuring longitudinally, and 7 in the same space transversely, arranged in longitudinal series.

The figures of the internal structure show that this form has all the characters of *Tæniodictya* with the exception that the interspaces are not transversely lined as in other species of the genus. This feature is one of age and its absence in the specimen studied may be due to its youthful condition.

The large zoœcia will distinguish this from other species of the genus. The only associated species with which it might be confused is *Pachydictya crassa*, but the oval aperture with thick ringlike walls and different internal structure of the latter are points of difference.

The specific name is in honor of Prof. Charles Schuchert, who collected the type specimen and to whom the writer is indebted for many favors.

Occurrence.—Rochester shale, Grimsby, Ontario.

Catalogue number, 35772, U. S. National Museum.

Family RHINIDICTYONIDÆ Ulrich.

Genus PACHYDICTYA Ulrich.

The species of this genus found in the Rochester shale is a cosmopolitan form which has been noted in most of the divisions of the Niagara. It is, therefore, of little value for purposes of exact correlation and marks the rocks of this group in general only.

PACHYDICTYA CRASSA (Hall).

Pl. XVIII, figs. 11, 12; Pl. XXI, figs. 14–16.

Stictopora crassa Hall, Nat. Hist. New York, Pal. II, 1852, p. 45, pl. 18, figs. 4 a–c.
Ptilodictya crassa Nicholson and Hinde, Canadian Journal, new ser., XIV, 1874.
Stictopora scitula Hall and Simpson, Nat. Hist. New York, Pal. VI, 1887, pl. 61, figs. 24, 25.
Pachydictya scitula Ulrich, Geol. and Nat. Hist. Survey Minnesota, Final Rept., III, pt. 1, 1893, p. 147.

The external features of this species have been well figured by Hall and Simpson and there is no difficulty in the identification of the form.

The zoarium consists of a narrow, dichotomously branching frond with sharp, parallel edges; branches elliptical in cross section with narrow noncelluliferous margins marked by faint striæ; zoœcial apertures oval, arranged in parallel longitudinal rows separated by linear ridges, 4 in 2 mm. measuring lengthwise.

The narrow bifoliate branches with large, rounded zoœcia distinguish the species from all associated forms.

Occurrence.—Common at all the Rochester shale localities in New York and Ontario; also very abundant in the Osgood beds at Osgood, Ind., as well as in the Niagaran rocks in general.

Catalogue numbers, 35754, 35755, U. S. National Museum.

Family RHABDOMESONTIDÆ Vine.

Genus ACANTHOCLEMA Hall.

Zoœcial tubes arising from a filiform axis in the center of the slender, ramose branches; apertures oval, in diagonally intersecting or linear series; acanthopores generally numerous.

ACANTHOCLEMA ASPERUM (Hall).

Pl. XXI, figs. 3-5; Pl. XXIV, figs. 7-9; Pl. XXV, figs. 17-20.

Trematopora aspera Hall, Nat. Hist. New York, Pal. II, 1852, p. 154, pl. 40A, figs. 10 a-c.
Batostomella? aspera Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, p. 189.

Zoarium of small cylindrical ramulets about 1 mm. in diameter. Surface smooth but, under a lens, hirsute because of the numerous acanthopores. Zoœcial apertures oval or elongate elliptical, usually 0.25 mm. in their longer diameter and 0.10 in the shorter, 4 in 2 mm. measuring lengthwise, arranged in rather regular longitudinal rows, of which there are 7 in 2 mm. Acanthopores numerous, as many as 8 or 10 surrounding an aperture and often inflecting it.

The main features brought out in vertical sections are the growth of the zoœcial tubes from a filiform axis, the small inferior hemiseptum, and the thick, laminated deposit of the interzoœcial spaces traversed by the acanthopores. Tangential sections through the mature region show the numerous acanthopores and thick interzoœcial tissue, while deeper sections reveal the rhomboidal shape of the primitive zoœcia.

This very abundant species might be confused with the equally abundant *Batostomella granulifera*, but the larger zoaria, smaller and more numerous acanthopores, less regularly arranged zoœcia, and interzoœcial spaces occupied by mesopores are points of difference. Internally the two are widely different.

Occurrence.—Rochester shale at Lockport, Rochester, and Niagara Falls, N. Y.; Grimsby, Hamilton, and Thorold, Ontario; Osgood beds at Osgood, Ind.

Catalogue numbers, 35756, 44149, U. S. National Museum.

Family ARTHROSTYLIDÆ Ulrich.

Genus NEMATOPORA Ulrich.

The following is a well-developed species of this genus, differing but little from some of the Ordovician forms. *Nematopora* is distinguished from other members of the Arthrostylidæ in that the zoarium is continuous instead of jointed above the pointed basal extremity.

NEMATOPORA MINUTA (Hall).

Pl. XVIII, fig. 10. Pl. XXI, figs. 8-11.

Trematopora ? (Trachypora) minuta Hall, Twenty-eighth Ann. Rept. New York State Mus. (doc. ed.), pl. 11, fig. 8.
Trematopora minuta Hall, Twenty-eighth Ann. Rept. New York State Mus. (Mus. ed.), p. 113, pl. 11, fig. 8.
Trematopora minuta Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., p. 234, pl. 10, fig. 8.
Nematopora minuta Ulrich, Geol. Survey Illinois, VIII, p. 645.

In the Rochester shale collections numerous examples of a single species of *Nematopora* have been observed, which, upon comparison with the type of Hall's *Trematopora minuta*, from the Niagaran at Waldron, Ind., have proved to belong to the same species.

Original description. Bryozoum ramose, very slender; branches frequent, widely diverging; diameter, 0.5 millimeter. Cell apertures elongate-oval, length about 0.4 mm., and width 0.2 mm.; distance from each other longitudinally about equal to the length of an aperture, arranged in spiral rows along the branch. Margins distinctly elevated and granulose, and separated from each other by tortuous lines of nodes.

To the above description may be added the following: The zoarium is ramose, but the lower end is pointed for attachment in a base spread over other objects. Measuring longi-

tudinally 5 to 6 zoœcia may be counted in 2 mm. Thin sections (see Pl. XXI, figs. 8–11) show that the species has all the internal characters of *Nematopora*.

In the small size of the zoarium and in the arrangement of the zoœcia they are quite different from associated bryozoa with the exception of *Acanthoclema asperum* (Hall). The latter, however, may readily be distinguished by its more robust growth, stronger granules or acanthopores, and less regularly arranged zoœcia. Internally the two are quite different.

Occurrence.—Rather uncommon in the Waldron shale at Waldron, Ind. More abundant in the Rochester shale at all of the localities in western New York and Ontario.

Catalogue numbers, 35773, 35774, U. S. National Museum.

Family RHINOPORIDÆ Ulrich.

This family was established provisionally by Ulrich [a] for the reception of the unique Silurian generic type *Rhinopora* Hall, the bifurcating structures traversing the surface of the type species, *R. verrucosa*, being so different from any known bryozoan that the genus could not be classified otherwise. Since that time Mr. Ulrich and the writer, while investigating the subject of Paleozoic bryozoa in general, discovered that the family could with slight emendation include three other genera, namely, *Stictotrypa* Ulrich, *Diamesopora* Hall, and *Lichenalia* Hall. It was also at this time that the relations and structure of the last two genera mentioned were ascertained. Up to this time *Diamesopora* was supposed to be congeneric with *Coelodema* Ulrich, an Ordovician genus belonging to the Ceramoporidæ, while *Lichenalia* was regarded as a synonym of *Fistulipora* McCoy. *Stictotrypa*, although placed under the Ptilodictyonidæ, had always proved a troublesome genus to locate naturally. The four genera now constituting the Rhinoporidæ have a few characters somewhat at variance, but when reduced to their simplest terms, all agree in possessing the following cryptostomatous characters: Oblong or rhomboidal zoœcia, direct vestibules, and hemisepta, the latter, however, being but little developed. *Rhinopora* is a broad bifoliate type, *Diamesopora* forms hollow ramose branches, *Stictotrypa* has narrow bifoliate branches, and the growth of *Lichenalia* is in semicircular, unilaminate expansions.

The first opportunity to publish the new information concerning the Rhinoporidæ occurred in United States Geological Survey Bulletin No. 173, where, with the kind permission of Mr. Ulrich, Nickles and the writer gave short emended descriptions of the family and the genera constituting it. For convenience of reference, these descriptions are repeated below in their respective places.

With the emendations pointed out above, the family Rhinoporidæ may now be defined as follows:

Zoarium variable in form; zoœcia prone along the basal membrane, simple, oblong, or rhomboidal; vestibules direct, hemisepta wanting or almost so; front of zoœcia below vestibule commonly strengthened with solid or vesicular tissue.

Genus RHINOPORA Hall.

Two species considered by their authors as members of this genus have been described from the Rochester shale. The first, *Rhinopora tuberculosa* Hall, is now known, from an examination of the type specimen by the writer, to belong to *Fistulipora*, while the second, *Rhinopora curvata* Ringueberg, seems to be a true member of the genus.

The generic characters of *Rhinopora* are as follows. Zoarium forming large, undulating bifoliate expansions, celluliferous on both sides; surface usually smooth, rarely with solid monticules, and traversed by slender, rounding, bifurcating ridges, which appear as shallow grooves when the surface is worn; apertures nearly circular, occupying the summits of prominent papillæ; mesopores present, but closed at the surface; large median tubuli in the mesotheca.

[a] Geol. Survey Illinois, VIII, 1890, p. 388.

RHINOPORA CURVATA Ringueberg.

Pl. XXII, figs. 12, 13.

Rhinopora curvata Ringueberg, Bull. Buffalo Soc. Nat. Hist., V, 1886, p. 19, pl. 2, fig. 14.

Original description.—Corallum very thin; foliate. Cells round or roundish oval, placed near the upper side of the thin pustulate calices that rise gradually from the surface at their lower side, thereby giving an upward direction to the cells. The cells are arranged closely in regular rows that cross each other diagonally; thus making a quincunx disposition of them; the regularity of the rows is sometimes disturbed by the bifurcation of a row as the frond increased in size.

Curve amounting to the width of three rows in one-half inch. Cells seven to one-eighth of an inch in the rows.

This coral bears some resemblance to *R. verrucosa* of the Clinton group; which differs, however, in the cells being much more prominent, the pustulose character being more defined, rising abruptly from the surface, in having the cell opening centrally located, and by its small cells.

Rhinopora curvata may be readily distinguished from all associated Rochester shales species by its broad, bifoliate growth, large zoœcia (4 in 2 mm., measuring along the diagonal rows), with the posterior portion of the peristome considerably elevated, and the arrangement of the apertures in well-defined diagonal lines.

Only a few specimens of this species have been studied, and none of these exhibits the characteristic covered canals of typical *Rhinopora*. Otherwise, however, the internal structure is essentially the same, and also differs in no way but method of growth from that of *Lichenalia*.

Occurrence.—Rochester shale, Lockport, N. Y., and Grimsby, Ontario.

Catalogue number, 35767, U. S. National Museum.

Genus LICHENALIA Hall.

Lichenalia Hall, Nat. Hist. New York, Pal. II, 1852, p. 171.

Lichenalia Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, p. 54. (Not *Lichenalia* of other authors.)

This genus was founded by Hall upon thin, epithecated, subcircular expansions occurring in the Rochester shale at Lockport, designated by him as *Lichenalia concentrica*. In parting the shale, the rough celluliferous sides of these expansions naturally adhere more closely to the matrix, and as a result the noncelluliferous, epithecated side is usually observed. Associated epithecated bryozoa from Lockport and elsewhere have been referred to the species irrespective of any other character, and *Lichenalia concentrica* is usually quoted as a characteristic Niagaran fossil wherever the rocks of that formation are studied. Here the value of thin sections is demonstrated, as it is only by their aid that the true relations of *Lichenalia* could be definitely ascertained. Hall's original definitions of the genus and species are of value only in that the genotype is restricted to the thin, epithecated expansions occurring at Lockport and elsewhere in western New York. All his later definitions of the genus are based on species of *Fistulipora*, which are in no manner related to the original types of *Lichenalia*. A study of Hall's type of *L. concentrica* and of other examples from New York shows that the generic characters are as follows: "Zoarium a subcircular unilaminar expansion; zoœcia prostrate; elongate-subrhomboidal, with direct subtubular vestibules; apertures rounded, with peristome much elevated on the posterior side; interspaces depressed, (?) cellulose."

To this definition of Nickles and the writer may be added the following remarks. Thin sections show that, as in *Rhinopora*, the surface of *Lichenalia concentrica* is traversed by slender, bifurcating ridges which in reality are closed canals. These probably represent the maculæ of other bryozoa, and are more often seen in thin sections because, as mentioned above, the surface is seldom observed. The occurrence of these canals in both *Rhinopora* and *Lichenalia* and the other points of agreement of the two genera leave their different methods of growth as the only distinguishing character. The cellulose (?) interspaces mentioned in the above definition of the genus have been determined only by the study of thin sections. The few specimens showing the celluliferous face have been in

such a state of preservation or condition of growth that the interspaces have always appeared depressed and solid. From the manner in which the walls of the mesopores occupying the zoœcial interspaces have been inserted, as shown on Pl. XXII, their purpose seems to have been mainly that of a strengthening tissue.

Altogether, both *Lichenalia* and *Rhinopora* are unique types of bryozoa and, so far as known, are restricted to Niagaran strata. Species described under these generic names from other horizons seem in all instances to belong elsewhere.

Lichenalia concentrica Hall.

Pl. XXII, figs. 1-6; Pl. XXVI, figs. 7-10.

Lichenalia concentrica Hall, Nat. Hist. New York, Pal. II, 1852, p. 171, pl. 40E, figs. 5a-g.

As this is the genotype and apparently the only valid species of the genus, the specific characters are as given in the generic diagnosis. The thin, unilaminate zoarium, large zoœcia (averaging 0.5 mm. in their longer diameter), and the meandering surface canals, are characters making the species easily recognized. Good specimens can be found only in the unweathered shales, and, in parting the shales, usually the epithecated side alone is shown. The disintegrated shales yield small fragments, but these, especially when still partly covered with clay, bring out the fact that the posterior portion of the zoœcial wall is unusually high. On account of the unusual structure shown in this type, the species is figured in detail.

Occurrence.—A characteristic fossil of the Rochester shale at Lockport, Rochester, and other localities in western New York. Good specimens may also be had at Grimsby, Ontario.

Catalogue number, 35775, U. S. National Museum.

Genus STICTOTRYPA Ulrich.

Zoarium ramose, not pointed at the base; branches dichotomously dividing, narrow, compressed; apertures circular or elliptical, with distinct, usually evenly elevated peristomes; interspaces flat or concave, composed of horizontally laminated solid tissue.

Stictotrypa punctipora (Hall).

Pl. XXII, figs. 7-11; Pl. XXIV, figs. 26, 27.

Stictopora punctipora Hall, Nat. Hist. New York, Pal. II, 1852, p. 157, pl. 40B, figs. 2a-c.
Stictotrypa punctipora Ulrich, Geol. Survey Illinois, VIII, 1890, p. 394, fig. 13a.

Hall and Ulrich (op cit.) have figured this species so well that its recognition is a matter of no difficulty. The more important of their figures, together with views of the internal structure, are given on the plates mentioned above.

The narrow, bifoliate zoarium, with branches averaging 3 mm. in width, and the elliptical zoœcial apertures with a well-marked peristome are so different from other bryozoa of this formation that comparison is not necessary. Measuring along one of the rows, 6 to 7 zoœcia may be counted in a space of 2 mm.

In thin sections the rhomboid or square shape of the primitive zoœcium, the blunt inferior hemiseptum, and the short cryptostomatous cell are well shown. With respect to these characters, thin sections of this species and *Diamesopora dichotoma* are strikingly similar, as a reference to the figures of the internal structure will show.

The various species of *Stictotrypa* resemble each other closely, but *S. punctipora* may readily be separated by the fact that the peristome is highest anteriorly, thus giving a notched appearance to the aperture.

Occurrence.—Rather abundant at Lockport, Rochester, and Niagara Falls, N. Y., Grimsby, Hamilton, and Thorold, Ontario.

Catalogue number, 35776, U. S. National Museum.

Genus DIAMESOPORA Hall.

Diamesopora Hall, Nat. Hist. New York, Pal. II, 1852, p. 158 (not defined).
Diamesopora Nickles and Bassler, Bull. U. S. Geol. Survey No. 173, 1900, p. 54.
Diamesopora Grabau, Bull. New York State Mus., IX, No. 45, 1901, p. 175.

Diamesopora Hall and Simpson, Nat. Hist. New York, Pal. VI, 1887, pp. xv, 19 (definition based on species of *Chilotrypa*).
Diamesopora Miller, North American Geol. and Pal., 1889, p. 30. (Includes, besides the genotype, species of *Cœloclema* and *Chilotrypa*.)
Diamesopora Simpson, Fourteenth Ann. Rept. State Geol. New York for the year 1894, 1897, p. 566. (Definition contains in part characters of both *Diamesopora* and *Chilotrypa*.)
Diamesopora Ulrich, Geol. Survey Illinois, VIII, 1890, pp. 380, 467; Geol. and Nat. Hist. Survey Minnesota, Final Rept. III, pt. 1, 1893, p. 330; Zittel's Textbook Pal. (Eng. ed.), 1896, p. 268 (= *Coeloclema*).

A study of thin sections of the genotype of Hall's *Diamesopora*, *D. dichotoma*, and of his *Trematopora osculum*, a related species found very abundantly in the Waldron shales in Indiana, showed, as indicated before, that the genus has until recently been misunderstood and incorrectly defined and classified. Ulrich proposed the name *Cœloclema* for similar, hollow-stemmed Ordovician species, but before defining the genus, abandoned it under the impression that his forms were congeneric with *D. dichotoma*. As the above synonymy shows, this author based his definition of *Diamesopora* more upon species of *Cœloclema* than upon the genotype. The two genera are now known to be so far removed from each other as to be classified under different orders, *Coeloclema* being a member of the Ceramoporidæ, a family of Cyclostomata, and *Diamesopora* having the rhomboidal primary zoœcia and tubular vestibule characteristic of the Cryptostomata.

Nickles and the writer (op. cit.) defined the genus as follows: "Zoarium ramose, of hollow stems lined internally by an epitheca; zoœcia simple, hexagonal, or rhomboidal, with an oval orifice in the anterior half, which, with growth, forms a tubular vestibule; apertures with peristomes equally elevated or highest posteriorly; intervestibular spaces compact or horizontally laminated."

The diagnostic characters are the mode of growth, the cryptostomatous zoœcia, tubular vestibule, and compact intervestibular space. Lunaria are absent, but their structures are simulated when the peristomes are highest posteriorly. A blunt superior hemiseptum is often found projecting from the zoœcial wall, but is seldom a conspicuous feature.

DIAMESOPORA DICHOTOMA Hall.

Pl. XXI, figs. 12, 13; Pl. XXIV, figs. 28–30.

Diamesopora dichotoma Hall, Nat. Hist. New York, Pal. II, 1852, p. 158, pl. 40B, figs. 3a–d.
Diamesopora dichotoma Grabau, Bull. New York State Mus., No 45, 1901, p. 175, fig. 78.

Fragments of this species are usually found as flattened branches crushed by pressure, but the normal zoarium is of smooth, hollow, ramose, cylindrical stems, 2 to 4 mm. in diameter, with the internal cavity now occupied by clayey matter.

The largest specimen seen shows that, as a rule, the zoaria seldom branches, a long straight stem of 4 or 5 cm. in length usually occurring. The crust forming the hollow zoarium is about 0.60 mm. in diameter, the interior or basal portion lined with a transversely striated basal membrane—the epitheca. Maculæ inconspicuous and only distinguished by the absence of zoœcial apertures. In young specimens the zoœcia are seen to be arranged in regularly ascending spiral lines, but the older the zoarium the more obscured becomes this arrangement. The zoœcia in young examples have well-marked peristomes generally elevated highest anteriorly, but these also become less conspicuous with age, and in many specimens the peristomes are not visible at all.

Internal characters.—Thin sections of this species are particularly instructive, since without them the cryptostomatous character of the genus would not be suspected. They show (1) that the primitive zoœcium is rhomboidal in outline, (2) that a tubular vestibule is developed in the anterior portion, (3) that at the junction of the posterior wall of the primi-

tive zoœcium and the vestibule, a blunt superior hemiseptum is sometimes developed, and (4) the investibular spaces are filled by a dense, horizontal, laminated tissue. The orifice is about 0.2 mm. in diameter, and counting along one of the spiral rows, 6 are found in 2 mm.

Occurrence.—Abundant at Lockport, Rochester, Lewiston, Niagara Falls, and other New York localities; also at Hamilton and Grimsby, Ontario.

Catalogue number, 35759, U. S. National Museum.

SYNONYMIC LIST OF SPECIES.

Acanthoclema asperum (Hall).
Allonema waldronense Ulrich and Bassler.
Ascodictyon radiciforme Vine. See Vinella radiciformis.
Ascodictyon siluriense (Vine).
Ascodictyon stellatum var. siluriense Vine. See Ascodictyon siluriense.
Aulopora consimilis Lonsdale. See Berenicea consimilis.
Batostomella? aspera Nickles and Bassler. See Acanthoclema asperum.
Batostomella granulifera (Hall).
Berenicea consimilis (Lonsdale).
Berenicea elegans Nickles and Bassler. See Berenicea consimilis.
Berenicea membranacea Nickles and Bassler. See Berenicea consimilis.
Bythopora spinulosa (Hall).
Callopora aspera Hall. See Lioclema asperum.
Callopora clausa n. sp.
Callopora elegantula Hall.
Callopora florida Hall. See Nicholsonella florida.
Callopora laminata Hall. See Fistulipora laminata.
Callopora magnopora Foerste.
Callopora nummiformis Hall. See Mesotrypa nummiformis.
Calloporella? nummiformis Ulrich. See Mesotrypa nummiformis.
Ceramopora foliacea Hall. See Meekopora foliacea.
Ceramopora imbricata Hall.
Ceramopora incrustans Hall. See Fistulipora crustula.
Ceramopora niagarensis n. sp.
Ceramopora orbiculata Ringueberg. See Ceramoporella orbiculata.
Ceramoporella irregularis n. sp.
Ceramoporella orbiculata (Ringueberg).
Chætetes expansus Ringueberg. See Orbignyella expansa.
Chilotrypa? coalescens Nickles and Bassler. See Chilotrypa ostiolata.
Chilotrypa ostiolata (Hall).
Clathropora alcicornis Hall.
Clathropora frondosa Hall.
Clathropora frondosa intermedia Nicholson and Hinde.
Clathropora intermedia Nicholson and Hinde. See Clathropora frondosa intermedia.
Cœloclema cavernosa n. sp.
Diamesopora dichotoma Hall.
Diastopora consimilis Vine. See Berenicea consimilis.
Diastoporella consimilis Vine. See Berenicea consimilis.
Diploclema sparsum (Hall).
Diploclema sparsum argutum n. var.
Diplotrypa milleri Ulrich. See Mesotrypa nummiformis.
Diplotrypa walkeri n. sp.
Drymotrypa diffusa Ulrich. See Pseudohornera diffusa.
Drymotrypa niagarensis Ulrich. See Pseudohornera niagarensis.
Eridotrypa nodulosa n. sp.

Eridotrypa similis n. sp.
Eridotrypa solida (Hall).
Eridotrypa spinosa n. sp.
Eridotrypa striata (Hall).
Fenestella cribrosa Hall.
Fenestella elegans Hall.
Fenestella nervata Nicholson. See Ptiloporella nervata.
Fenestella tenuiceps Hall. See Semicoscinium tenuiceps.
Fistulipora crustula n. sp. or n. name.
Fistulipora laminata (Hall).
Fistulipora lockportensis n. sp.
Fistulipora tuberculosa (Hall).
Homotrypa? solida Nickles and Bassler. See Eridotrypa solida.
Hornera? dichotoma Hall. See Thamniscus dichotomus.
Idiotrypa parasitica Ulrich. See Idiotrypa punctata.
Idiotrypa punctata (Hall).
Leioclema florida Ulrich. See Nicholsonella florida.
Leioclema? laminatum Ulrich. See Fistulipora laminata.
Leptotrypa maculata Ulrich. See Spatiopora maculata.
Lichenalia concentrica Hall.
Lioclema asperum (Hall).
Lioclema circinctum n. sp.
Lioclema explanatum n. sp.
Lioclema florida Grabau. See Nicholsonella florida.
Lioclema globulare n. sp.
Lioclema (?Nicholsonella) laminatum Nickles and Bassler. See Fistulipora laminata.
Lioclema multiporum n. sp.
Lioclema peculiare n. sp.
Lioclema ramulosum n. sp.
Lioclemella maccombi n. sp.
Loculipora ambigua precursor n. var.
Loculipora ulrichi n. sp.
Meekopora foliacea (Hall).
Mesotrypa milleri Nickles and Bassler. See Mesotrypa nummiformis.
Mesotrypa nummiformis (Hall).
Mitoclema sarlei n. sp.
Monotrypa benjamini n. sp.
Monotrypa osgoodensis n. sp.
Monotrypa pediculata n. sp.
Nematopora minuta (Hall).
Nicholsonella florida (Hall).
Nicholsonella ringuebergi n. sp.
Orbignyella expansa (Ringueberg).
Orbignyella magnopora n. sp.
Pachydictya crassa (Hall).
Pachydictya scitula Ulrich. See Pachydictya crassa.
Paleschara? aspera Hall. See Spatiopora maculata.
Paleschara maculata Hall. See Spatiopora maculata.
Phænopora ensiformis Hall.
Phænopora fimbrata canadensis n. var.
Phylloporina asperato-striata (Hall).
Polypora incepta Hall.
Pseudohornera diffusa (Hall).
Pseudohornera niagarensis (Hall).

Ptilodictya crassa Nicholson and Hinde. See Pachydictya crassa.
Ptilodictya ensiformis Ulrich. See Phænopora ensiformis.
Ptiloporella nervata (Nicholson).
Retepora asperato-striata Hall. See Phylloporina asperato-striata.
Retepora diffusa Hall. See Pseudohornera diffusa.
Rhinopora curvata Ringueberg.
Rhinopora tuberculosa Hall. See Fistulipora tuberculosa.
Rhombotrypa spinulifera n. sp.
Rhopalonaria attenuata Ulrich and Bassler.
Sagenella elegans Hall. See Berenicea consimilis.
Sagenella membranacea Hall. See Berenicea consimilis.
Semicoscinium tenuiceps (Hall).
Spatiopora maculata (Hall).
Stictopora crassa Hall. See Pachydictya crassa.
Stictopora dichotoma Whitfield and Hovey. See Thamniscus dichotomus.
Stictopora punctipora Hall. See Stictotrypa punctipora.
Stictopora scitula Hall and Simpson. See Pachydictya crassa.
Stictotrypa punctipora (Hall).
Stigmatella globata n. sp.
Stomatopora dissimilis Vine.
Stomatopora dissimilis elongata Vine. See Stomatopora elongata.
Stomatopora elongata (Vine).
Stomatopora parva Ringueberg. See Stomatopora elongata.
Stomatopora recta Ringueberg. See Stomatopora dissimilis.
Subretepora asperato-striata Miller. See Phylloporina asperato-striata.
Subretepora dichotoma Miller. See Thamniscus dichotomus.
Tæniodictya schucherti n. sp.
Thamniscus dichotomus (Hall).
Thamniscus? niagarensis Hall. See Pseudohornera niagarensis.
Trematopora aspera Hall. See Acanthoclema asperum.
Trematopora coalescens Hall. See Chilotrypa ostiolata.
Trematopora granulifera Hall. See Batostomella granulifera.
Trematopora ostiolata Hall. See Chilotrypa ostiolata.
Trematopora minuta (Hall). See Nematopora minuta.
Trematopora?? punctata Hall. See Idiotrypa punctata.
Trematopora solida Hall. See Eridotrypa solida.
Trematopora sparsa Hall. See Diploclema sparsum.
Trematopora spiculata Miller.
Trematopora spinulosa Hall (1852). See Bythopora spinulosa.
Trematopora spinulosa Hall (1876). See Trematopora spiculata.
Trematopora striata Hall. See Eridotrypa striata.
Trematopora tuberculosa Hall.
Trematopora whitfieldi Hall.
Vinella? multiradiata Ulrich and Bassler.
Vinella radiciformis (Vine).

PLATES III TO XXXI.

PLATE III.

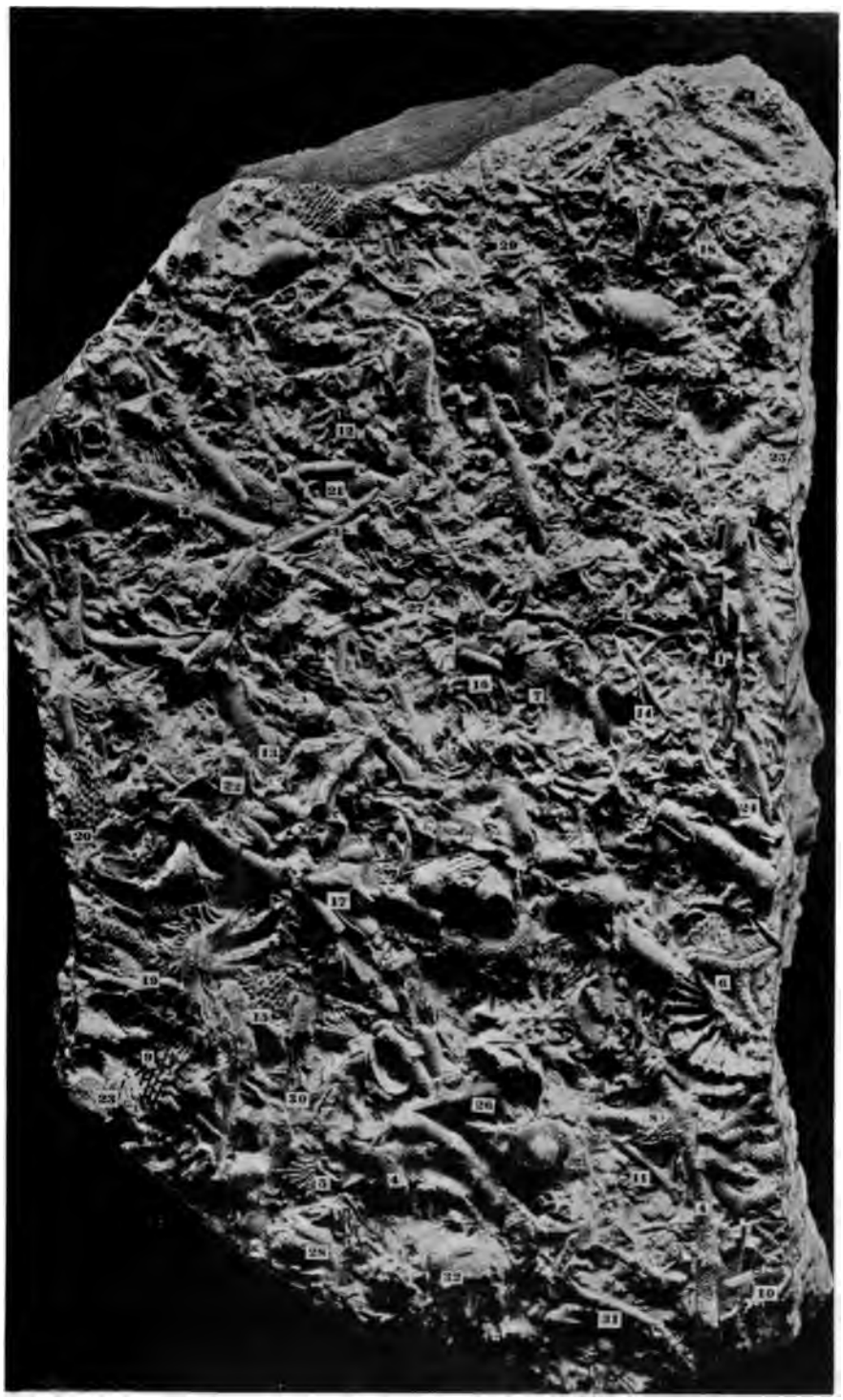
PLATE III.

View of a slab, × 1.4, showing assemblage of species.

Rochester shale, Middleport, N. Y.

All of the species recognized on this slab are designated by numbers, but the duplicate specimens, of which there are many, are left unnumbered. In spite of the numerous species showing upon this specimen, some of the most common forms, such as *Trematopora tuberculosa*, *Pachydictya crassa*, *Phylloporina asperato-striata*, etc., are unrepresented. Following is the list of species with their corresponding numbers:

1. Pseudohornera diffusa (Hall).
2. Diamesopora dichotoma (Hall).
3. Lioclemella maccombi n. sp.
4. Chilotrypa ostiolata (Hall).
5. Semicoscinium tenuiceps (Hall).
6. Bythopora spinulosa (Hall).
7. Callopora elegantula Hall.
8. Fenestella cribrosa Hall.
9. Polypora incepta Hall.
10. Phænopora ensiformis Hall.
11. Thamniscus dichotomus (Hall).
12. Pseudohornera niagarensis (Hall).
13. Stictotrypa punctipora (Hall).
14. Acanthoclema asperum (Hall).
15. Fenestella elegans Hall.
16. Idiotrypa punctata (Hall).
17. Lioclema asperum (Hall).
18. Diploclema sparsum (Hall).
19. Cœloclema cavernosa n. sp.
20. Loculipora ulrichi n. sp.
21. Tæniodictya schucherti n. sp.
22. Allonema waldronense Ulrich and Bassler.
23. Stigmatella globata n. sp.
24. Nematopora minuta (Hall).
25. Trematopora spiculata Hall.
26. Eridotrypa striata (Hall).
27. Ceramoporella orbiculata (Ringueberg).
28. Fistulipora crustula n. sp.
29. Diploclema sparsum argutum n. var.
30. Ptiloporella nervata (Nicholson).
31. Batostomella granulifera (Hall).
32. Lioclema multiporum n. sp.



BRYOZOA OF THE ROCHESTER SHALE

PLATE IV.

PLATE IV.[a]

Vinella? multiradiata Ulrich and Bassler. (Page 13.)

FIG. 1. Part of a colony attached to a crinoid column, exhibiting many nuclei and the intertwining of the numerous radiating stolons, × 9.
Rochester shale, Lockport, N. Y.

Vinella radiciformis (Vine). (Page 12.)

2. Portion of the creeping network of the typical form of this species, × 9, showing several nuclei.
Rochester shale, Lockport, N. Y.
3. A nucleus of another colony, × 20, showing a few scattered pores along the radii.
Rochester shale, Rochester, N. Y.

Rhopalonaria attenuata Ulrich and Bassler. (Page 11.)

4. Part of a colony preserved as an excavated mold, with several branches growing so as to intersect each other, thus causing an apparent irregularity in the growth.
5. Portion of another colony preserved as an excavated mold on a gastropod, showing a more regular arrangement of the zoœcia. Both figures illustrate the extreme tenuity of the connecting stolons and the very slight swelling of the zoœcial part.
Rochester shale, Lockport, N. Y.

Ascodictyon siluriense Vine. (Page 14.)

6. Two isolated clusters of vesicles, × 9, attached to a fragment of *Leptæna rhomboidalis*.
7. A group of clusters, × 9.
Rochester shale, Lockport, N. Y.
8. A single cluster, magnified, figured by Vine (Quart. Jour. Geol. Soc. London, XXXVIII, 1882, p. 52, fig. 1).
Wenlock shales, Shropshire, England.

Allonema waldronense Ulrich and Bassler. (Page 13.)

9. Portion of a colony attached to the dorsal valve of an orthoid.
Waldron shale, Waldron, Ind.

Stomatopora elongata (Vine). (Page 14.)

10. Three zoœcia, × 12, of a specimen identified by Mr. Vine.
11. Portion of a zoarium magnified. (After Vine.)
Wenlock shales, Shropshire, England.

12, 13. Portions of two zoaria, × 12, showing variation in growth and shape of zoœcia.

14. A specimen, × 6, introduced for comparison with figure 19.
Rochester shale, Rochester, N. Y.

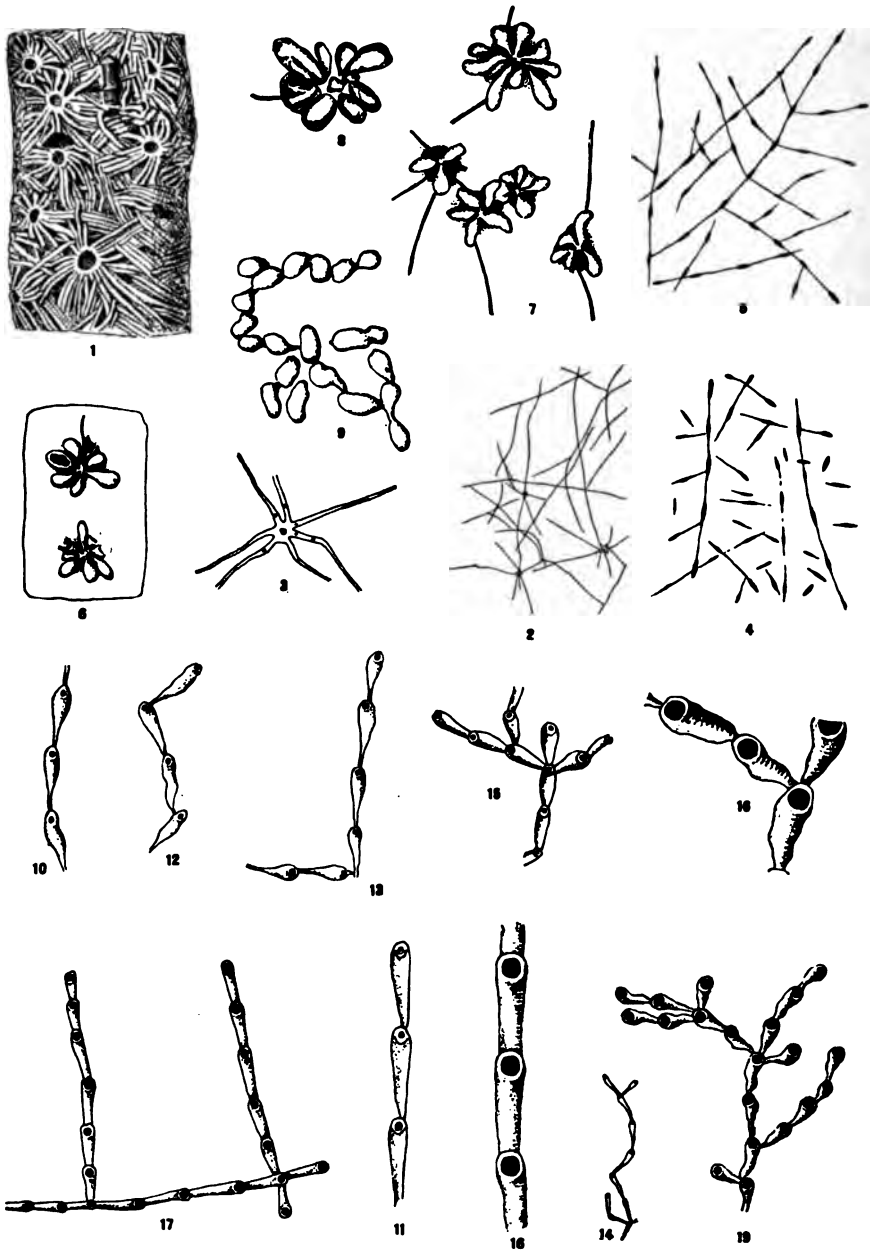
Stomatopora dissimilis Vine. (Page 15.)

15. A reduced sketch of one of Vine's figures of this species.
Wenlock shales, England.
16. Zoœcia, × 12, exhibiting transverse annulations and flexuous growth.

17, 18. A portion of a colony, × 6, and parts of four zoœcia of same, × 12.

19. Another colony, × 6.
Rochester shale, Lockport, N. Y.

[a] Figs. 1, 2, 4, 5, 6, and 9 are copied from Ulrich and Bassler, Revision of American Paleozoic Bryozoa, Ctenostomata; Smithsonian Miscellaneous Collections (Quart. issue), XLV, 1904.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE V.

PLATE V.

Berenicea consimilis (Lonsdale). (Page 16.)

FIG. 1. Portion of a zoarium, × 6, incrusting a *Meristella* and showing radiate arrangement of zoœcia about centers of growth.
Silurian, island of Gotland.

2. Copy of Vine's illustration of this species.
Wenlock shales, England.

3, 4. Hall's figures of this species published under the name "An incrusting membrano-calcareous Coral" (Nat. Hist. New York, Pal. II, 1852, pl. 40 *E*, figs. 8, 8a).
Rochester shale, Lockport, N. Y.

5. Several zoœcia, × 20, of the Waldron form described by Hall as *Sagenella elegans*.
Waldron shale, Newsom, Tenn.

Diploclema sparsum (Hall). (Page 17.)

[See also Pl. XXXIII figs. 4-6.]

6, 7. Two fragments, natural size and × 9, of this abundant species showing the usual external features.
Rochester shale, Lockport, N. Y.

Diploclema sparsum argutum n. var. (Page 17.)

8. A portion of a zoarium, × 12, exhibiting the greater number of ranges of zoœcia and pore in front of the aperture, distinguishing this variety.

9. Several zoœcia of same with apertural pore.
Rochester shale, Lockport, N. Y.

Mitoclema sarlei n. sp. (Page 18.)

10, 11, 12. Three fragmentary examples of this small species, natural size and × 9.
Rochester shale, Rochester, N. Y.

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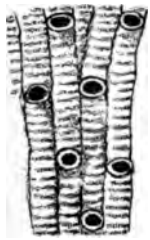

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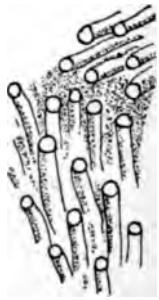

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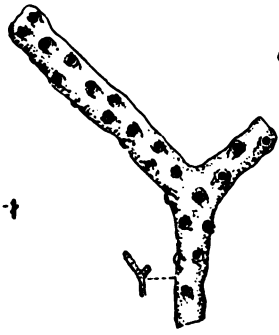

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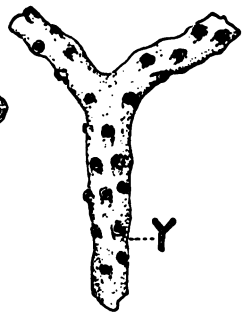

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BRYOZOA OF THE ROCHESTER SHALE.

PLATE VI.

PLATE VI.

Ceramopora imbricata Hall. (Page 19.)

FIG. 1. Tangential section, × 18, showing the irregular mesopores and peculiar wall structure.

2. Tangential section, × 18, passing through the porous basal layer, showing the cellulose character.

3. Portion of a vertical section, × 8, showing the cellulose basal layer and the openings in the walls of the zoœcia.

Figs. 1-3 are after Ulrich, Geological Survey Illinois, VIII, 1890.

4. A vertical section, × 10, cutting across the zoarium, showing growth about a crinoid column, and the structure of zoœcia and basal layer.

5, 6. Celluliferous surfaces of two zoaria, × 2, composed of single maculæ.

Osgood beds, Osgood, Ind.

7. A zoarium, × 2, showing several maculæ.

8. Basal view of a zoarium, × 2, showing the spongy nature and the cicatrix of attachment.

9, 10. A macula and a portion of another part of the surface of a zoarium enlarged, to show the imbricating character of the zoœcia.

Rochester shale, Lockport, N. Y.

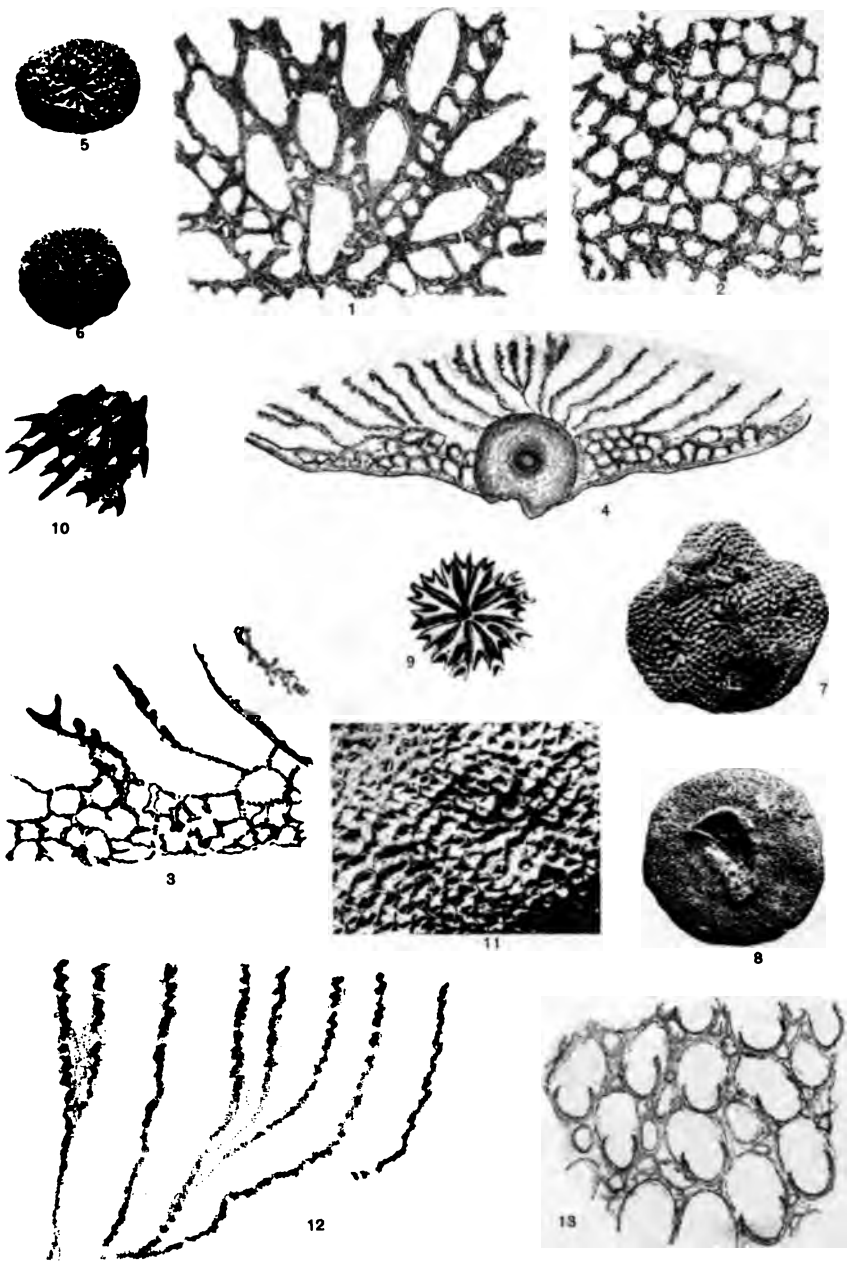
Figs. 9 and 10 are after Hall, Natural History of New York, Paleontology II, 1852.

Ceramopora niagarensis n. sp. (Page 19.)

11. Surface of one of the types, × 8.

12, 13. Vertical and tangential sections, × 20, showing the characteristic ceramoporoid structure.

Rochester shale, Rochester, N. Y.



BRYOZOA OF THE ROCHESTER SHALE

PLATE VII.

PLATE VII.

Fistulipora lockportensis n. sp. (Page 23.)

FIGS. 1, 2. Tangential and vertical sections, respectively, ×20, illustrating internal characters of the species.

3. Surface view of one of the types, × 8, showing a macula and surrounding zoœcia.

Rochester shale, Lockport, N. Y.

Fistulipora laminata (Hall). (Page 22.)

[See also Pl. VIII, figs. 9, 10.]

4, 5. Vertical and tangential sections, × 20.

6. Surface of Hall's figured type, × 8.

Rochester shale, Lockport, N. Y.

Fistulipora crustula n. sp. (Page 24.)

[See also Pl. VIII, figs. 16, 17; Pl. XXIII, fig. 15.]

7. Tangential section, × 20, including a portion of a macula and showing the small but prominent lunaria.

8. Vertical section, × 20, showing both immature and mature regions.

9. Surface of a typical specimen showing portion of a macula and the surrounding zoœcia.

10. A tangential section, × 20, passing close to the surface where the apertures are inclosed by polygonal areas.

Rochester shale, Lockport, N. Y.

Fistulipora tuberculosa (Hall). (Page 23.)

[See also Pl. VIII, figs. 7, 8; Pl. XXIII, fig. 14.]

11. Tangential section, ×20, exhibiting the small, bi-lobed zoœcia.

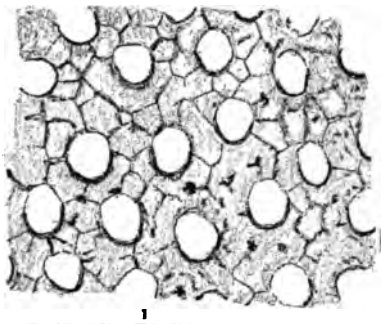
12. Vertical section, × 20, passing through one of the sides of the utricular zoarium.

13. Portion of a tangential section, × 20, prepared from Hall's figured type.

14. Surface of Hall's figured type, × 8.

15. A vertical section, × 6, to show the growth in hollow stems. The sides of the zoarium are brought nearer together than in the specimen in order to save space.

Rochester shale, Lockport, N. Y.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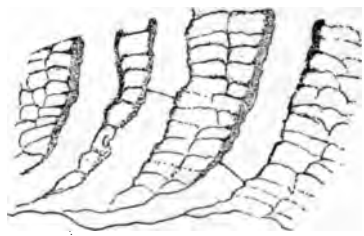
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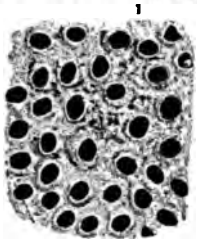
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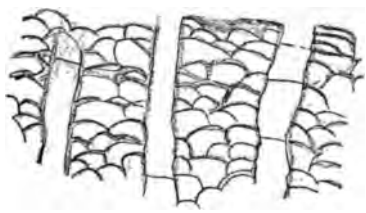
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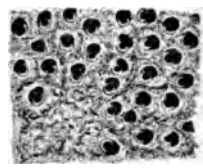
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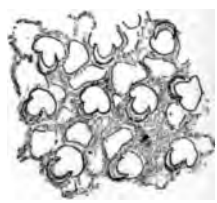
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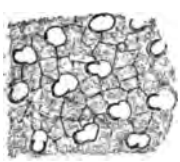
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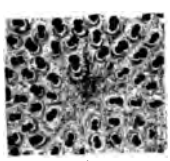
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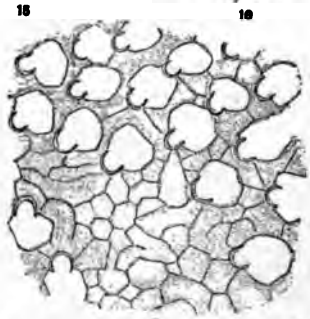
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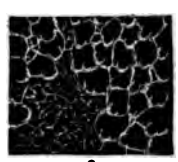
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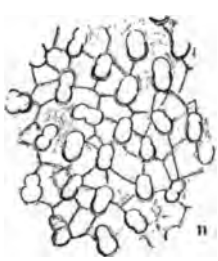
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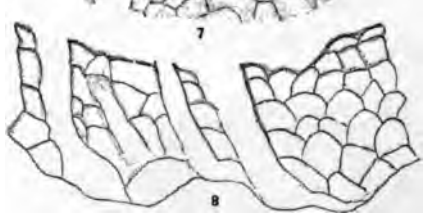
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BRYOZOA OF THE ROCHESTER SHALE.

PLATE VIII.

PLATE VIII.

[Unless otherwise stated, all the figures on this plate are copied from Hall, Nat. Hist. New York, Pal. II, 1852.]

Spatiopora maculata (Hall). (Page 22.)

[See also Pl. IX, figs. 10, 11.]

FIG. 1. One of Hall's types of *Paleschara maculata*, natural size; bryozoan incrusting a *Platyostoma*:

2. Surface enlarged.

(Figs. 1 and 2 after Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist. 1882.)
Waldron shale, Waldron, Ind.

3. Zoarium incrusting a *Stephanocrinus*, natural size.

4. Surface of same enlarged.

(Species figured by Hall, but not named.)
Rochester shale, Lockport, N. Y.

Meekopora foliacea (Hall). (Page 25.)

[See also Pl. IX, figs. 5, 6.]

5. Hall's type of *Ceramopora foliacea*, natural size.

6. Surface of same, enlarged, showing arrangement of zoœcial apertures and digitate maculæ.
Rochester shale, Lockport, N. Y.

Fistulipora tuberculosa (Hall). (Page 23.)

[See also Pl. VIII, figs. 11-15; Pl. XXIII, fig. 14.]

7. View of type, natural size, of *Rhinopora tuberculosa* Hall. This zoarium is a crushed utricular specimen.

8. Enlarged view of same showing arrangement of apertures and tubercules.
Rochester shale, Lockport, N. Y.

Fistulipora laminata Hall. (Page 22.)

[See also Pl. VII, figs. 4-6.]

9, 10. Upper (celluliferous) and basal (epithecated) sides, respectively, of the original type of *Callopora laminata* Hall, natural size.
Rochester shale, Lockport, N. Y.

Chilotrypa ostiolata (Hall). (Page 24.)

[See also Pl. IX, figs. 1-4.]

11. Type of *Trematopora coalescens* Hall, natural size, which proves to be the basal portion of *Chilotrypa ostiolata*.

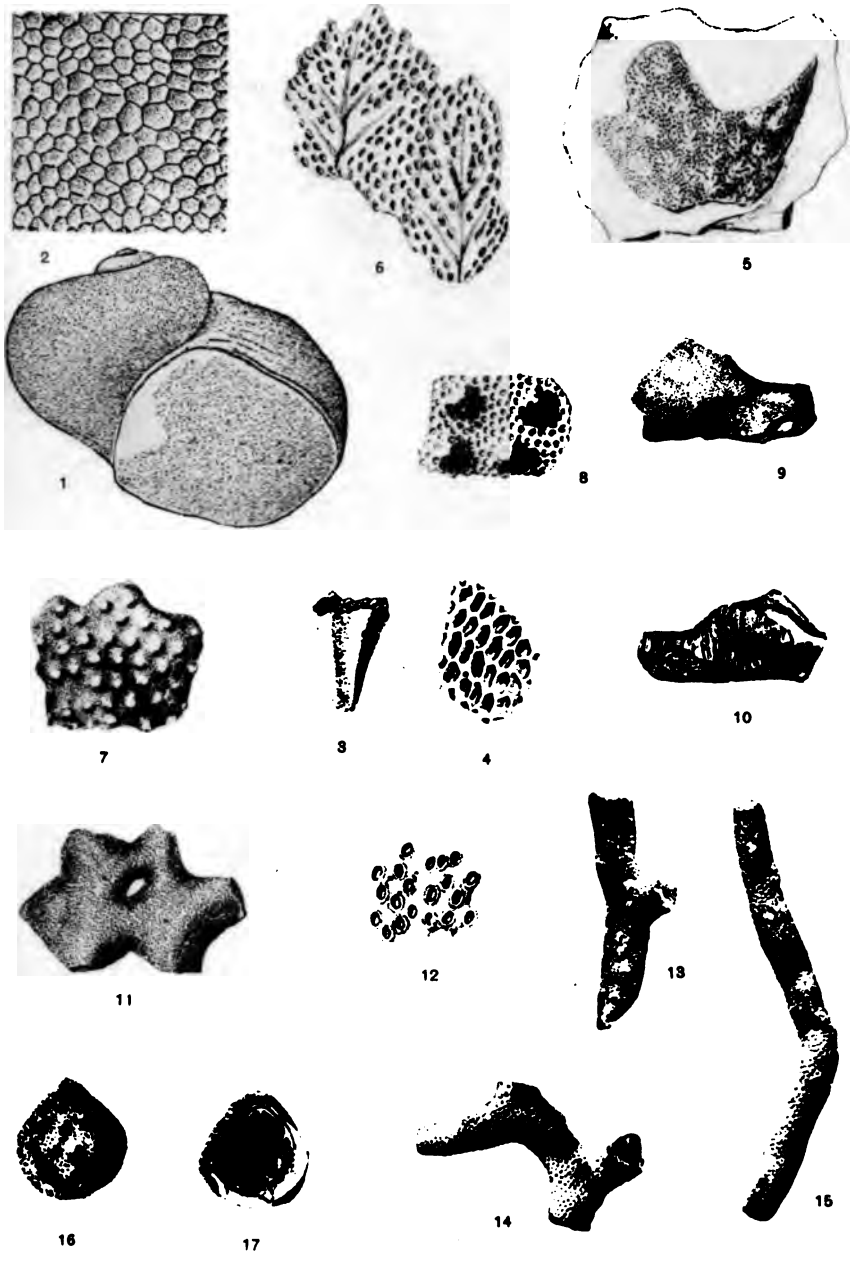
12. Surface of same enlarged.

13, 14, 15. Three typical examples of *Chilotrypa ostiolata*, × 2. (Original.)
Rochester shale, Lockport, N. Y

Fistulipora crustula n. sp. (Page 24.)

[See also Pl. VII, figs. 7-10; Pl. XXIII, fig. 15.]

16, 17. Views of the surface and of the interior of the shell incrusted of Hall's type of *Ceramopora incrustans*.
Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE

PLATE IX.

PLATE IX.

Chilotrypa ostiolata (Hall). (Page 24.)

[See also Pl. VIII, figs. 11-15.]

FIG. 1. Surface of a typical example, × 20, showing portion of a macula and the surrounding zoœcia.

2. A transverse section, × 20.

3. Tangential section, × 20.

4. A vertical section, × 20, illustrating the central canal, the peculiar bend of the zoœcia in the immature region, and the vesiculose interspaces of the mature region.

In figs. 2 and 4 the central canal is darkened in order to show it more clearly.
Rochester shale, Lockport, N. Y.

Meekopora foliacea (Hall). (Page 25.

[See also Pl VIII, figs. 5, 6.]

5, 6. Tangential and vertical sections, respectively, × 20, showing the fistuli-poroid character and bifoliate growth of this species.
Rochester shale, Lockport, N. Y.

Ceramoporella irregularis n. sp. (Page 21.)

7. Tangential section, × 20, illustrating the prominent crescentic lunaria, rather numerous mesopores, and thin-walled zoœcia.

8. Vertical section, × 20, showing two layers of zoœcia

9. Surface of the type specimen, × 8.
Rochester shale, Lockport, N. Y.

Spatiopora maculata (Hall). (Page 22.)

[See also Pl. VIII figs. 1 4.]

10. A tangential section of an old example, × 20.

11. Surface of a less mature example, × 8, in which the zoœcia show the characteristic lineate arrangement.
Waldron shale, Waldron, Ind.

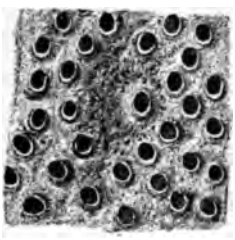
Ceramoporella orbiculata (Ringueberg). (Page 20.)

12. Vertical section, × 20.

13. A tangential section, × 20, cutting the zoarium below the surface and showing the usual mesopores at this height.

14. Surface of a typical example, × 8, showing a portion of a macula and the polygonal area marking out the zoœcia in mature specimens.

15. A portion of fig. 14, × 20.
Rochester shale, Lockport, N. Y.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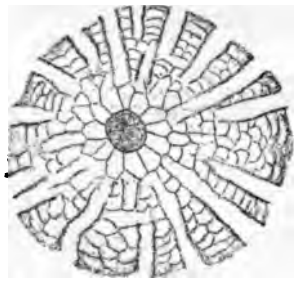
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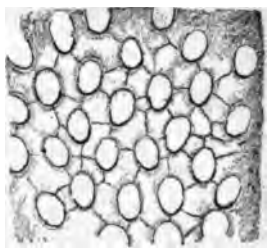
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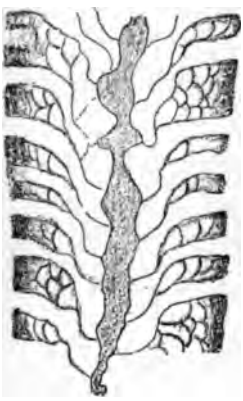
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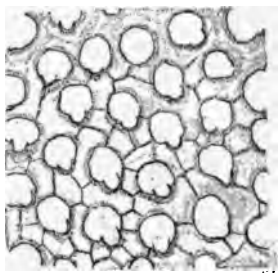
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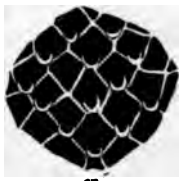
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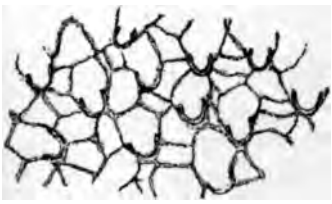
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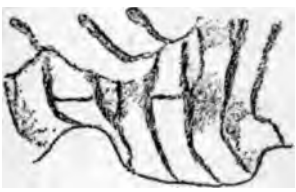
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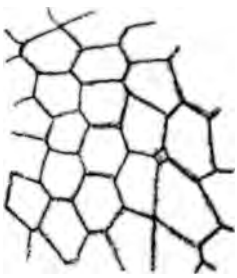
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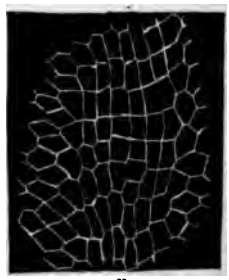

11

BRYOZOA OF THE ROCHESTER SHALE.

PLATE X.

PLATE X.

Mesotrypa nummiformis (Hall). (Page 27.)

FIGS. 1, 2. Tangential and vertical sections, respectively, × 20.

3. Top and edge views of specimens, natural size, to show the characteristic growth.

4. Surface of the original of fig. 3, × 8.

Rochester shale, Lockport, N. Y.

Orbignyella expansa (Ringueberg). (Page 26.)

5. Vertical section, × 20, of a typical example with the usual development of curved diaphragms.

6. Tangential section, × 20, through the mature region, exhibiting the large zoœcia of a portion of a macula, and the smaller intermacular zoœcia.

7. Several intermacular zoœcia, × 30, with the characteristic wall structure well developed.

8. Surface of Ringueberg's type, × 8.

Rochester shale, Lockport, N. Y.

Orbignyella magnopora n. sp. (Page 27.)

9, 10. Vertical and tangential sections, × 20, exhibiting the comparatively few curved diaphragms and the large, thin-walled zoœcia characteristic of the species.

11. Several zoœcia of a tangential section, × 20, giving the appearance when the curved diaphragms are cut.

12. Surface of type specimen, × 8, exhibiting the large, thin-walled zoœcia by which externally the species can be separated from the associated *O. expansa*.

Rochester shale, Grimsby, Ontario.

Rhombotrypa spinulifera n. sp. (Page 37.)

[See also Pl. XXV, fig. 21.]

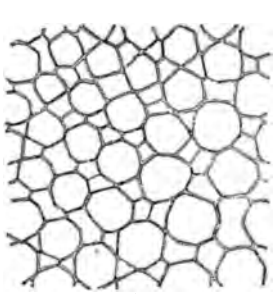
13. Vertical section, × 20, exhibiting the zones caused by the turning of the zoœcia at regular intervals.

14. Tangential section, × 20, cutting the mature region where the mesopores are well developed.

15. A few zoœcia and mesopores, × 35, of a section passing through the most mature portion of the zoarium and showing the acanthopores distinguishing this from other species of the genus.

16. A portion of a transverse section, × 20, exhibiting the quadrate shape of the zoœcia in the immature zone.

Rochester shale, Lockport, N. Y.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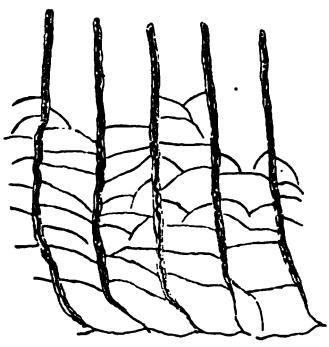
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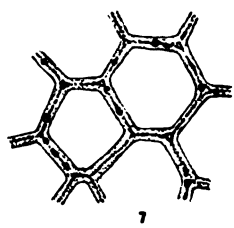
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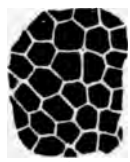
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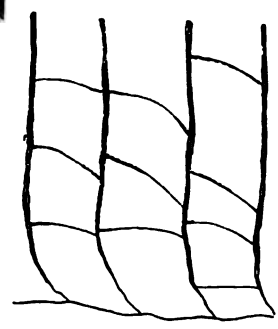
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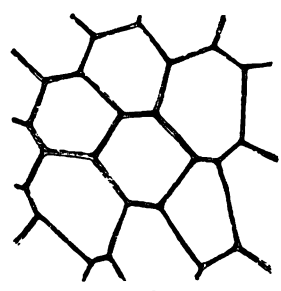
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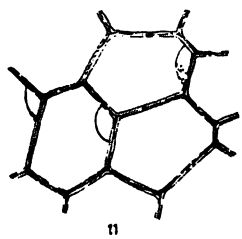
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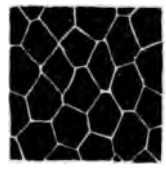
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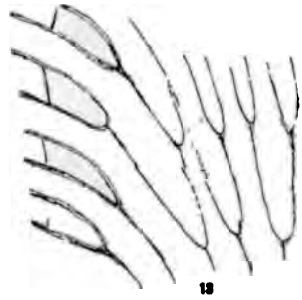
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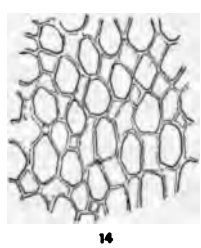
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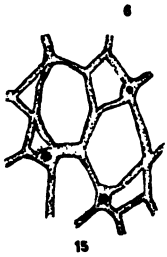
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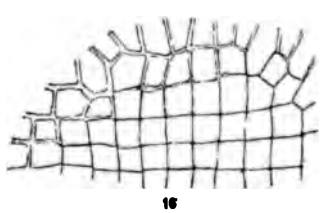
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BRYOZOA OF THE ROCHESTER SHALE.

PLATE XI.

PLATE XI.

Lioclema asperum Hall. (Page 32.)

[See also Pl. XXIV, figs. 14-16.]

FIG. 1. A vertical section, × 20, passing through an immature and portions of two mature regions.

2. Tangential section, × 20, illustrating the general features of the mature region.

3. A portion of a tangential section, × 35, showing the structure of the walls and of the numerous large acanthopores.

Rochester shale, Lockport, N. Y.

Lioclema multiporum n. sp. (Page 34.)

[See also Pl. XXIII, fig. 18; Pl. XXVII, fig. 20.]

4. A small portion of a tangential section, × 20, passing through the mature region.

5. A vertical section, × 20, showing the characters of both immature and mature regions.

6. A portion of the tangential section figured in 4, × 35, introduced for comparison with the corresponding figure of *L. asperum*.

Rochester shale, Lockport, N. Y.

Lioclemella maccombi n. sp. (Page 36.)

[See also Pl. XXV, figs. 5-7.]

7. Vertical section, × 20, with the usual tabulation of zoœcia and mesopores.

8, 9. Tangential section, × 20, and a portion of same, × 30, illustrating the shape of the zoœcia and structure of the walls.

10. Surface of one of the figured types, × 8.

Rochester shale, Lockport, N. Y.

Lioclema ramulosum n. sp. (Page 35.)

[See also Pl. XXV, figs. 9, 10.]

11. Vertical section, × 20, illustrating the apparent absence of diaphragms.

12, 13. Tangential section, × 20, and a portion of same, × 30, showing the general arrangement and structure of the zoœcia and mesopores and of the few but large acanthopores.

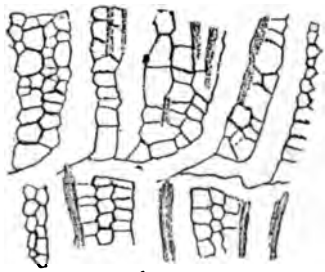
Rochester shale, Lockport, N. Y.

Eridotrypa nodulosa n. sp. (Page 30.)

[See also Pl. XXV, figs. 1-3.]

14, 15. Tangential and vertical sections, respectively, × 20, illustrating the internal characters of a mature example.

Rochester shale, Lockport, N. Y.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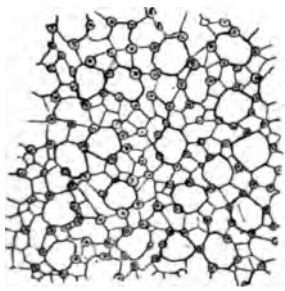
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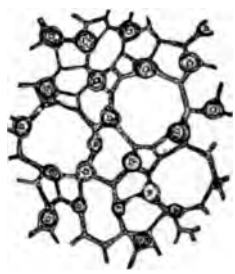
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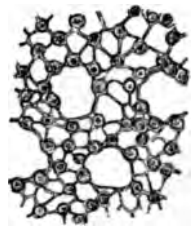
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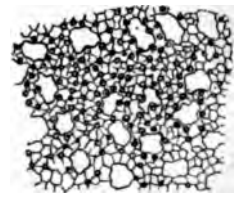
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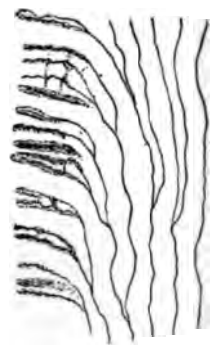
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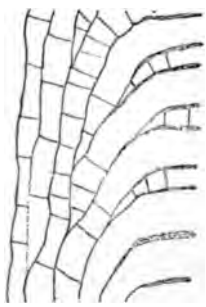
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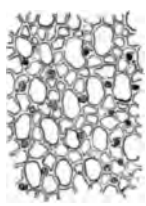
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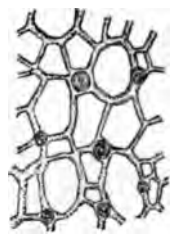
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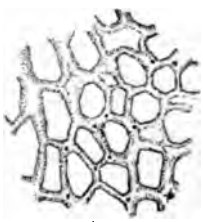
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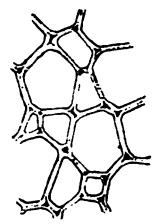
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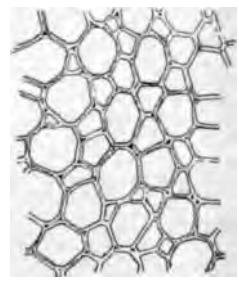
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BRYOZOA OF THE ROCHESTER SHALE.

PLATE XII.

PLATE XII.

Eridotrypa spinosa n. sp. (Page 29.)

[See also Pl. XXV, fig. 15.]

FIG. 1. Vertical section, × 20, showing the tabulation and the thick zoœcial walls of the mature region.

2, 3. Two portions of a tangential section, × 20, exhibiting the thick zoœcial wells, large numerous acanthopores, and the variation in the number of mesopores.

Rochester shale, Grimsby, Ontario.

Eridotrypa striata (Hall). (Page 32.)

[See also Pl. XXIV, figs. 3-6; Pl. XXV, fig. 14.]

4. Vertical section, × 20, showing the characteristic tabulation and the slight thickening of the walls in the mature region.

5, 6. Portions of two tangential sections, × 20, showing the appearance of the youthful and aged conditions, respectively, of the mature region.

Rochester shale, Lockport, N. Y.

Eridotrypa solida (Hall). (Page 30.)

[See also Pl. XXIV, figs. 20-23; Pl. XXV, fig. 16.]

7. Vertical section, × 20, showing the usual absence of diaphragms and slight thickening of walls in the mature region.

8, 9. Two portions of a tangential section, × 20, showing the angular zoœcia and mesopores of the mature zone.

Rochester shale, Lockport, N. Y.

Eridotrypa similis n. sp. (Page 31.)

[See also Pl. XXVI, figs. 1, 2.]

10. A tangential section, × 20, with the usual thick-walled angular zoœcia and mesopores and characteristic acanthopores.

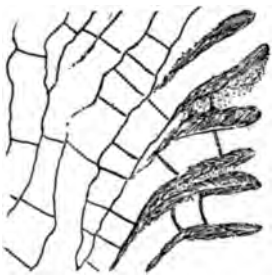
11. Vertical section, × 20, exhibiting few diaphragms in the zoœcial tubes and more numerous ones in the mesopores.

12. A tangential section, × 30, passing through a macula.

13. Another tangential section showing more numerous acanthopores and mesopores than usual.

14. Surface of one of the figured types, × 8.

Rochester shale, Grimsby, Ontario.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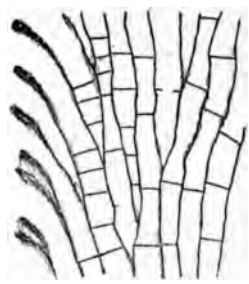
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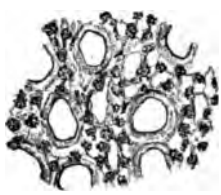
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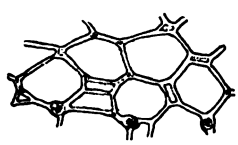
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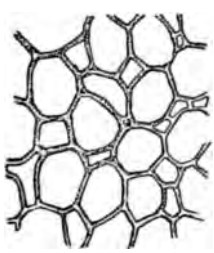
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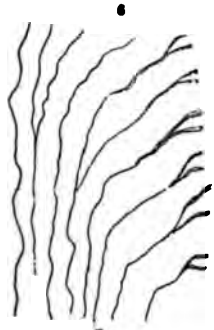
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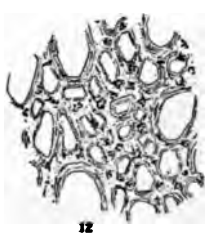
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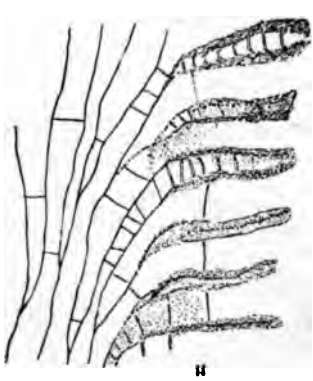
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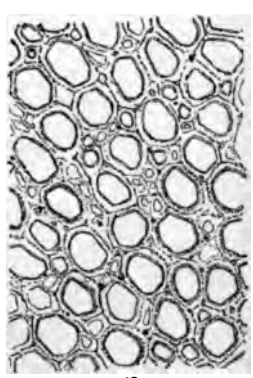
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BRYOZOA OF THE ROCHESTER SHALE.

PLATE XIII.

PLATE XIII.

Batostomella granulifera (Hall). (Page 28.)

[See also Pl. XXIV, figs. 10, 11; Pl. XXV, figs. 11, 12.]

FIG. 1. Tangential section, × 20, showing the solid interzoœcial spaces and numerous acanthopores.

2. Another tangential section, × 20, taken lower in the mature region where the acanthopores are smaller and the mesopores are visible.

3. Tangential section, × 30, showing the wall structure with the mesopores faintly visible.

4, 5. Vertical section, × 20 and × 30, respectively, exhibiting the usual internal features.

Rochester shale, Lockport, N. Y.

Bythopora spinulosa (Hall). (Page 29.)

[See also Pl. XXIV, figs. 12, 13.]

6, 7. Tangential and vertical sections, × 20.

Rochester shale, Lockport, N. Y.

Lioclema explanatum n. sp. (Page 33.)

[See also Pl. XXVI, fig. 4.]

8. Surface of one of the types, × 16.

9. Tangential section, × 20, showing the thin-walled zoœcia, numerous mesopores, and comparatively few acanthopores.

10. Vertical section, × 20, exhibiting the tabulation of zoœcia and mesopores.

Rochester shale, Rochester, N. Y.

Lioclema circinctum n. sp. (Page 34.)

11. Vertical section, × 20, of the type specimen, showing two successive layers of zoœcia.

12. Tangential section, × 20, bringing out the unusually numerous mesopores and apparent absence of acanthopores.

13, 14. Small portion of fig. 12, × 60, and a portion of wall of same, × 75, exhibiting the peculiar wall structure.

Rochester shale, Lockport, N. Y.

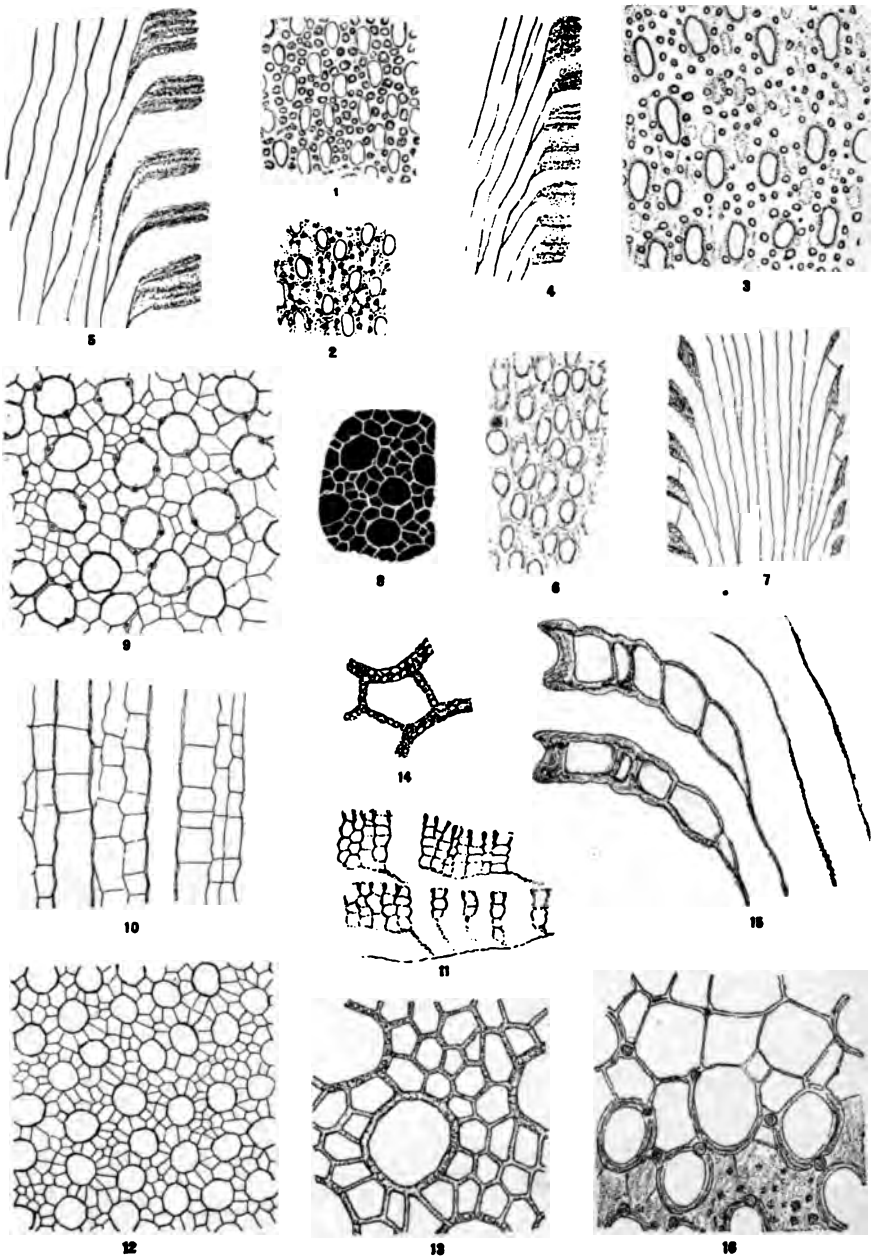
Trematopora tuberculosa Hall. (Page 43.)

[See also Pl. XVII, figs. 1-3; Pl. XXV, fig. 8.]

15. A few zoœcia of a vertical section, × 35, exhibiting the beadlike constrictions of the mesopores.

16. Several zoœcia of a tangential section, × 35, showing the minute structure of the walls and acanthopores.

Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE XIV.

PLATE XIV.

Diplotrypa walkeri n. sp. (Page 47.)

[See also Pl. XXV, fig. 4.]

FIG. 1. Tangential section, × 20, showing the usual number of mesopores and the differences in the size of the zoœcia.

2, 3. Vertical sections, × 20, exhibiting slight variations in the tabulation of mesopores and zoœcia.

4. Portion of fig. 1, × 40.

5. Surface view of one of the types, × 8.

Rochester shale, Grimsby, Ontario.

Stigmatella globata n. sp. (Page 28.)

6. Tangential section, × 20, passing through one of the zones of acanthopores and illustrating the thin walls and comparatively few acanthopores and mesopores.

7. A portion of fig. 6, × 40, exhibiting the structure and size of the acanthopores and the characteristic amalgamation of the zoœcial walls.

8. Vertical section, × 20, cutting two zones of acanthopores.

9. Surface view of the sectioned type, × 8.

Rochester shale, Lockport, N. Y.

Nicholsonella florida (Hall). (Page 38.)

[See also Pl. XXIV, figs. 1, 2.]

10. Tangential section, × 20, illustrating the large acanthopores indenting the zoœcial apertures.

11. Vertical section through a small portion of an immature region and all of a mature region, × 20.

Rochester shale, Lockport, N. Y.

Nicholsonella ringuebergi n. sp. (Page 39.)

12. Tangential section, × 20, through the mature region. The zoœcial cavities are blackened in order to bring out more clearly the indentation of the walls by the acanthopores.

13. Vertical section, × 20, passing through an entire zoarium.

Rochester shale, Lockport, N. Y.

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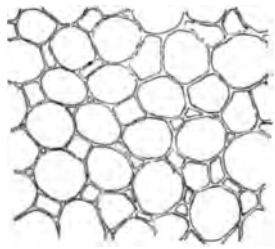
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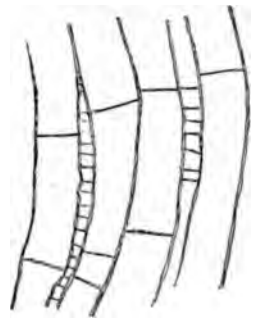
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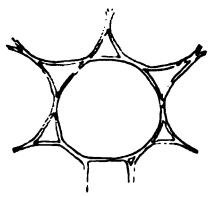
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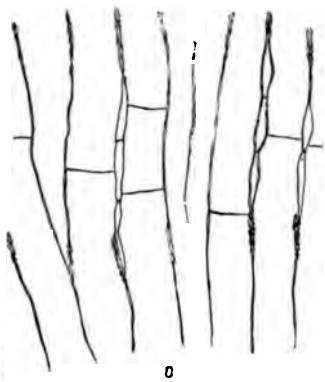
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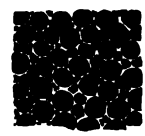
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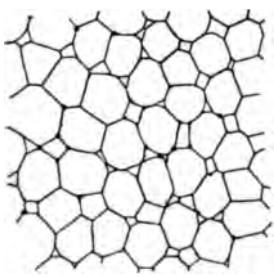
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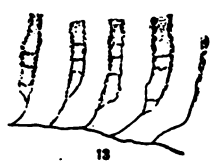
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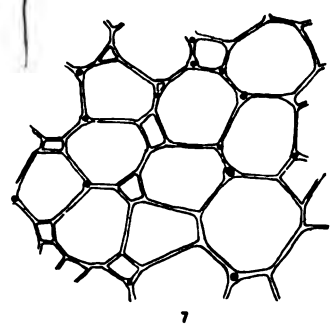
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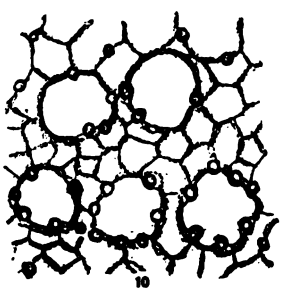
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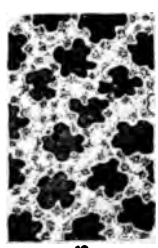
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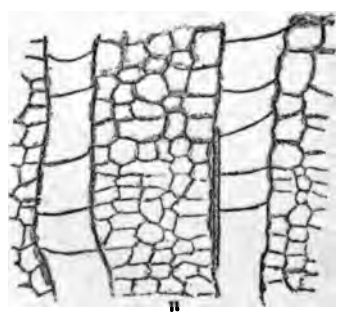
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BRYOZOA OF THE ROCHESTER SHALE.

PLATE XV.

PLATE XV.

Callopora magnopora Foerste. (Page 42.)

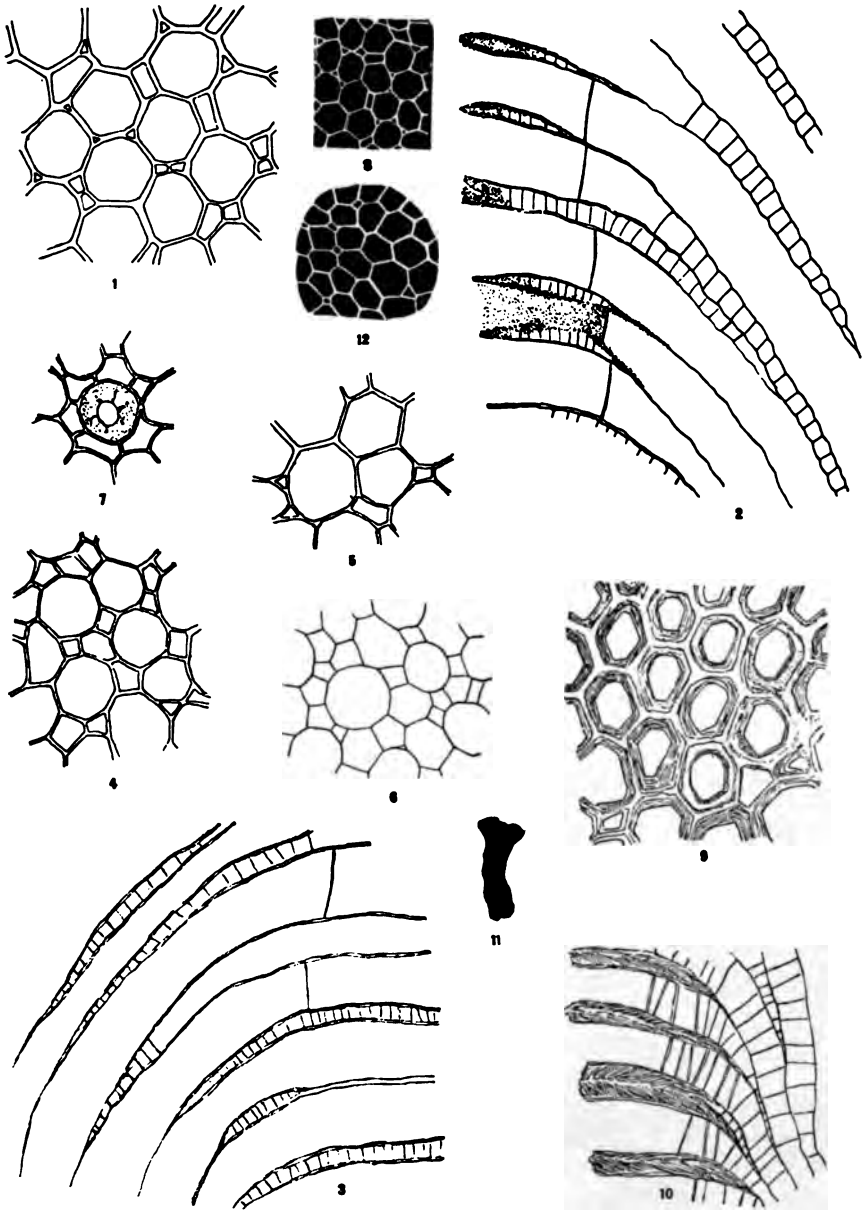
[See also Pl. XXVI, fig. 3.]

FIGS. 1, 2. Tangential and vertical sections, × 20, of an authentic specimen.
Clinton formation, Dayton, Ohio.

3. Vertical section, × 20, showing the characteristic tabulation of the species.
4. A small portion of a tangential section, × 20, cutting the mature region at a zone where the mesopores are well developed.
5. Several zoœcia and mesopores, × 20, of a tangential section taken near the surface of the zoarium where the mesopores are few in number.
6. Portion of a transverse section, × 20, showing the shape of the zoœcia and mesopores in the immature zone.
7. A single zoœcium from a deep tangential section, × 20, passing through a diaphragm and indicating that the opercula seen at the surface became diaphragms as growth proceeded.
8. Surface of a typical example, × 8.
Rochester shale, Grimsby, Ontario.

Callopora clausa n. sp. (Page 42.)

9. Tangential section, × 20, illustrating the polygonal rather thick-walled zoœcia and few mesopores.
10. Vertical section, × 20, showing characteristic tabulation of zoœcia and mesopores and disappearance of the latter as the surface is approached.
11. A typical example, natural size.
12. Surface of same, × 8. Here only the crests of the zoœcial walls are shown, the walls themselves being considerably thicker.
Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE XVI.

PLATE XVI.

Monotrypa osgoodensis n. sp. (Page 46.)

FIGS. 1, 2. Portions of two vertical sections, × 20, exhibiting the tabulation and other characteristics of the immature and mature zones, respectively.

3. Tangential section, × 20, passing through the mature region.
Osgood beds, Osgood, Ind.

4. Top and side views of a zoarium, natural size.

5. Surface of a typical example, × 8.
Rochester shale, Lockport, N. Y.

Monotrypa benjamini n. sp. (Page 46.)

[See also Pl. XXVI, fig. 11.]

6. Vertical section, × 20, showing the characteristic crenulations of the zoœcial walls.

7. A tangential section, × 20, passing through the immature region.

8. A tangential section, × 20, cutting the mature region. Here the thickness of the walls has been somewhat increased by a secondary deposit.
Rochester shale, Lockport, N. Y.

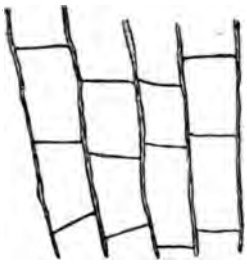
9. A small portion of a vertical section, × 20, passing through the immature region.
Osgood beds, Osgood, Ind.

Monotrypa pediculata n. sp. (Page 47.)

10, 11. Vertical and tangential sections, × 20, showing the internal structure.

12. Surface of one of the types, × 8.

13. Two complete zoaria, natural size, showing the striated basal portion.
Rochester shale, Rochester, N. Y.



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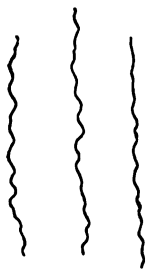

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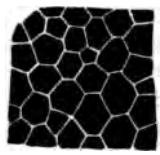

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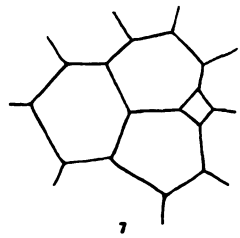

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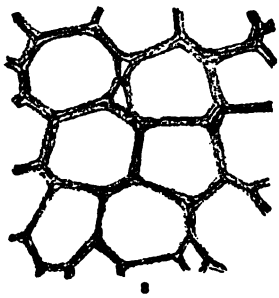

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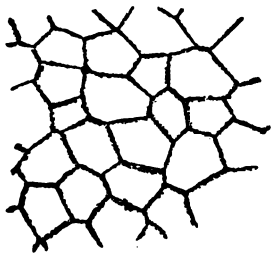

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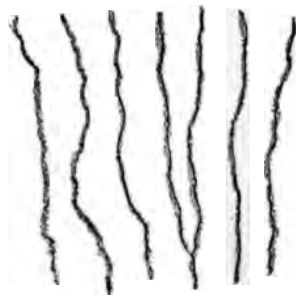

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BRYOZOA OF THE ROCHESTER SHALE.

PLATE XVII.

PLATE XV.

PLATE XVIII.

PLATE XVIII.

Phylloporina asperato-striata (Hall). (Page 48.)

FIGS. 1, 2. A small fragment, natural size, and the surface enlarged.
3. A more complete zoarium, natural size, showing the noncelluliferous side.
4, 5. Two enlargements of the noncelluliferous side, exhibiting the asperate striate character which suggested the specific name.
Rochester shale, Lockport, N. Y.

Pseudohornera diffusa (Hall). (Page 50.)

[See also Pl. XXIII, figs. 1-3.]

6, 7. Views of Hall's types, natural size.
8. A portion of the noncelluliferous striated surface enlarged.
9. An enlargement of the celluliferous face showing the arrangement and form of the zoœcia.
Rochester shale, Lockport, N. Y.

Nematopora minuta (Hall). (Page 58.)

[See also Pl. XXI, figs. 8, 9.]

10. Hall's type, natural size and enlarged.
Waldron shale, Waldron, Ind.

Pachydictya crassa (Hall). (Page 57.)

[See also Pl. XXI, figs. 14-16.]

11, 12. Two enlargements of a fragment of this species, figured by Hall and Simpson as *Stictopora scitula*.
Rochester shale, Lockport, N. Y.

Loculipora ambigua (Hall). (Page 53.)

13. An almost complete zoarium, natural size.
14, 15. Enlarged views of the opposite faces of the same specimen showing slight differences in the character of each.
16. An enlargement from the edge of specimen illustrated by fig. 13.
Waldron shale, Waldron, Ind.

Thamniscus dichotomus (Hall). (Page 54.)

[See also Pl. XXVII, figs. 1-7.]

17, 18. One of Hall's types, natural size, and enlargement of the same.
The supposed original of these figures, as stated on page 54, proves to be a small example of *Pachydictya crassa*.
19. An enlarged view of the striated noncelluliferous face of Hall's second type of the species.
Rochester shale, Lockport, N. Y.

Pseudohornera niagarensis (Hall). (Page 49.)

[See also Pl. XIX, figs. 14-16.]

20. View of a specimen of this species, natural size, figured by Hall as *Fenestella*.
Rochester shale, Lockport, N. Y.

All the figures on this plate are copied from Hall, figs. 1–9 and 17–20 being from Natural History of New York, Paleontology II, 1852; figs. 11 and 12 from Vol. VI of the same series; and figs. 10 and 13–16 from Eleventh Annual Report of the State Geologist of Indiana, 1882.

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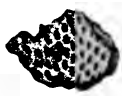

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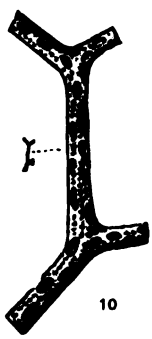

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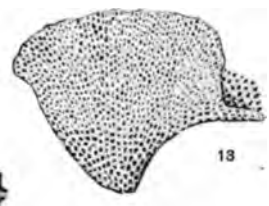

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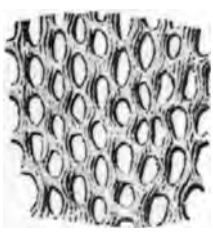

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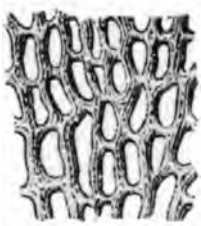

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BRYOZOA OF THE ROCHESTER SHALE

HELIOTYPE CO., BOSTON.

PLATE XIX.

PLATE XIX.

Unless otherwise stated all the figures on this plate are copied from Hall, Nat. Hist. New York, Pal. II, 1852.]

Fenestella elegans Hall. (Page 51.)

FIG. 1. A frond, natural size, showing the noncelluliferous side.
2. Celluliferous side of another specimen, enlarged.
Rochester shale, Lockport, N. Y.

Fenestella cribrosa Hall. (Page 50.)

3. Fragment, natural size, exposing noncelluliferous face.
4. Portion of same enlarged.
5. Celluliferous face of another example, × 20, showing protruding zoœcia, conspicuous spines on carina, and broad branches. (Original).
Rochester shale, Lockport, N. Y.

Semicoscinium tenuiceps (Hall). (Page 52.)

6. Basal view, natural size, showing funnel-shaped zoarium with carinated celluliferous face.
7. Celluliferous surface of a specimen enlarged, with the carina worn or less developed than usual, thus exposing the zoœcial apertures more clearly.
Rochester shale, Lockport, N. Y.

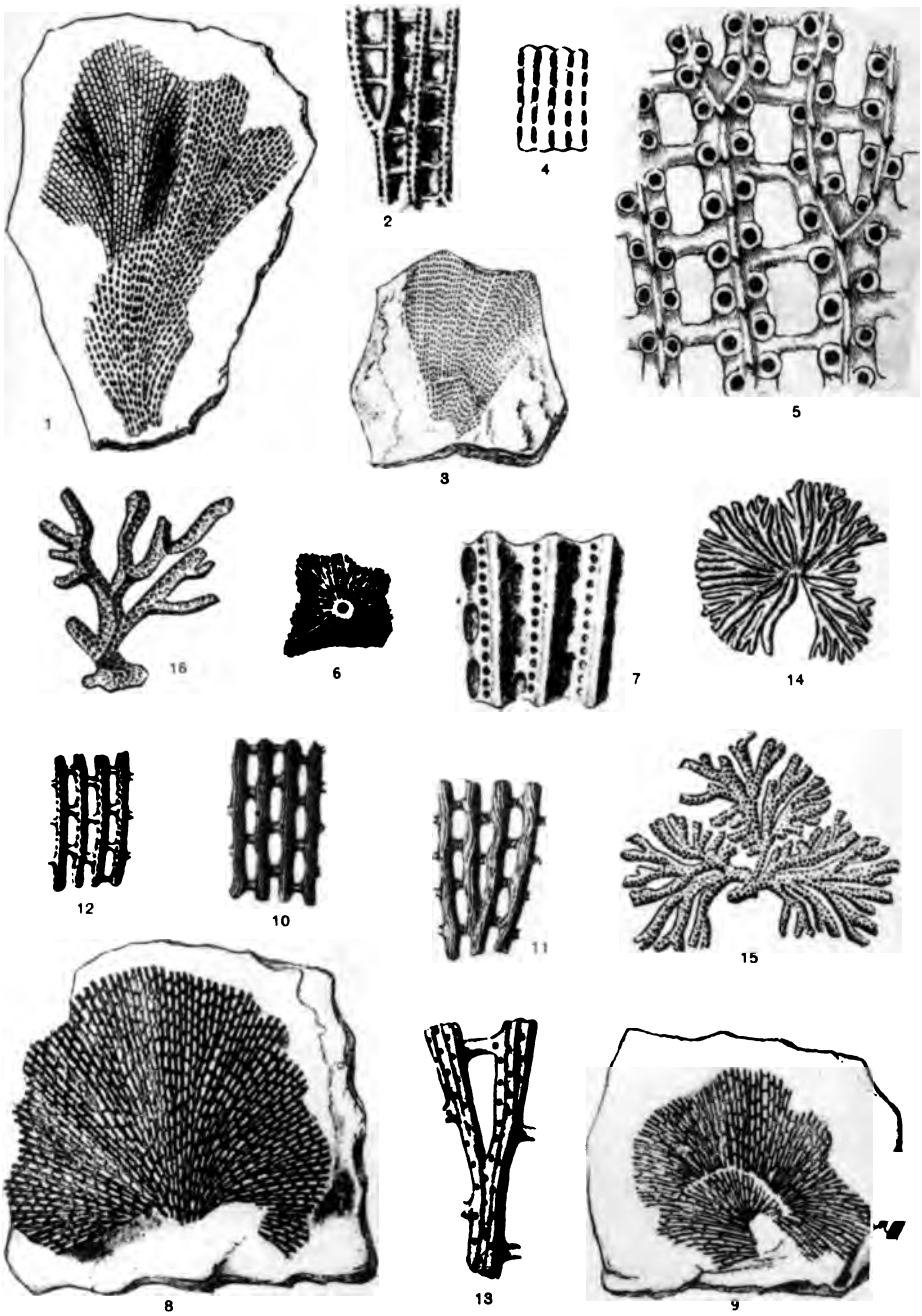
Polypora incepta Hall. (Page 52.)

8, 9. Two zoaria, natural size, both exhibiting the noncelluliferous surface.
10, 11. Noncelluliferous side enlarged to show striated surface.
12. 13. Two enlargements of the celluliferous face, exhibiting number of rows and arrangement of zoœcial apertures.
Rochester shale, Lockport, N. Y.

Pseudohornera niagarensis (Hall). (Page 49.)

[See also Pl. XVIII, fig. 20.]

14. Noncelluliferous face, natural size.
15. Celluliferous face of another example, × 2.
16. Fragment of another zoarium, × 3, showing basal attachment and angular crest.
Figs. 14–16 after Hall, Eleventh Ann. Rept. Indiana Geol. Nat. Hist., 1882.
Waldron shale, Waldron, Ind.



BRYOZOA OF THE ROCHESTER SHALE

PLATE XX.

PLATE XX.

Clathropora alcicornis Hall. (Page 56.)

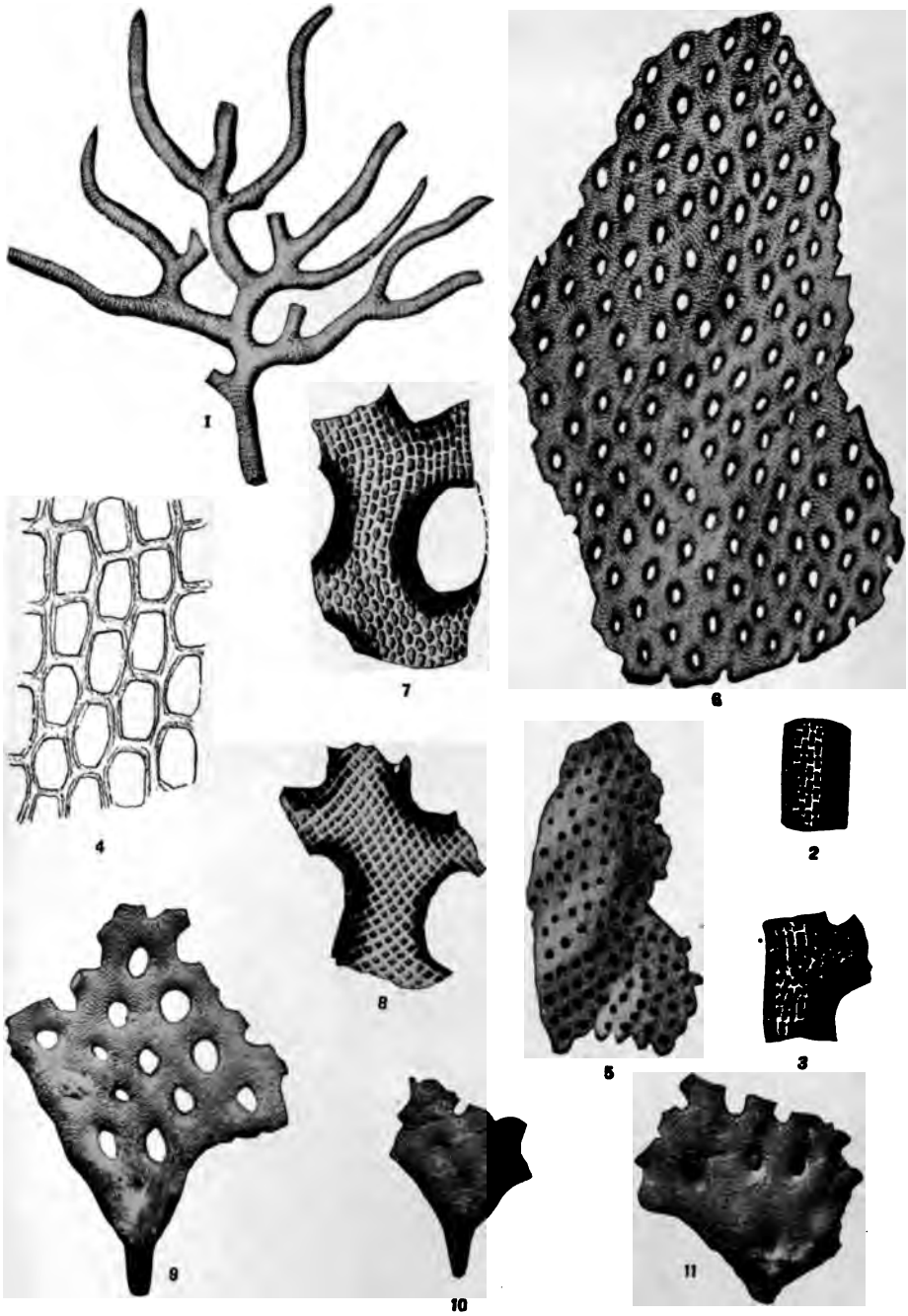
FIG. 1. A view of the type specimen, natural size.
2, 3. Enlarged views of the surface of the same.
4. A tangential section of the type specimen, × 30, showing its generic identity with *Clathropora*.
Rochester shale, Lockport, N. Y.

Clathropora frondosa Hall and var. *intermedia* Nicholson and Hinde. (Page 56.)

[See also Pl. XXI, figs. 6, 7.]

5. A view of the type specimen of the small fenestruled form, which Nicholson and Hinde apparently considered as typical *C. frondosa*.
6. Natural-sized view of another of Hall's type specimens, later distinguished by Nicholson and Hinde as var. *intermedia*.
7, 8. Enlarged view of the surface, showing the zoœcial characters in both species and variety.
9, 10, 11. Three fragments of zoaria, showing the pointed basal extremity
Rochester shale, Lockport, N. Y.

Figs. 1, 2, 3, 5, 6, 7, 8 are after Hall, Natural History of New York, Palæontology II, 1852.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE XXI.

PLATE XXI.

Loculipora ambigua (Hall). (Page 53.)

FIG. 1. An outline sketch, natural size, illustrating the growth of this species and introduced for comparison with fig. 2.
Waldron shale, Waldron, Ind.

Loculipora ulrichi n. sp. (Page 53.)

2. Sketch of a zoarium, natural size, showing the narrow elongate basal portion.
Rochester shale, Grimsby, Ontario.

Acanthodema asperum (Hall). (Page 58.)

[See also Pl. XXIV, figs. 7-9; Pl. XXV, figs. 17-20.]

3. Vertical section, × 20, showing the growth of the zoœcia from a central line.
4. Tangential section, × 20, passing through the mature region and illustrating the elongate-oval zoœcia, solid interspaces, and numerous granular-like acanthopores.
5. Transverse section, × 20, exhibiting the zoœcia radiating from the central axis.
Rochester shale, Lockport, N. Y.

Clathropora frondosa Hall. (Page 56.)

[See also Pl. XX, figs. 5-11.]

6. A vertical section, × 20, illustrating the bifoliate growth, the hemisepta, and the general shape of the zoœcia.
7. Tangential section, × 20, with the characteristic wall structure of the genus.
Rochester shale, Lockport, N. Y.

Nematopora minuta (Hall). (Page 58.)

[See also Pl. XVIII, fig. 10.]

8, 9. Two tangential sections passing through portions of mature region and exhibiting the long, oval zoœcia and the numerous small acanthopores
10. Vertical section, × 20.
11. A portion of fig. 10, × 40, illustrating the acanthopores piercing the interzoœcial thickening.
Rochester shale, Grimsby, Ontario.

Diamesopora dichotoma Hall. (Page 62.)

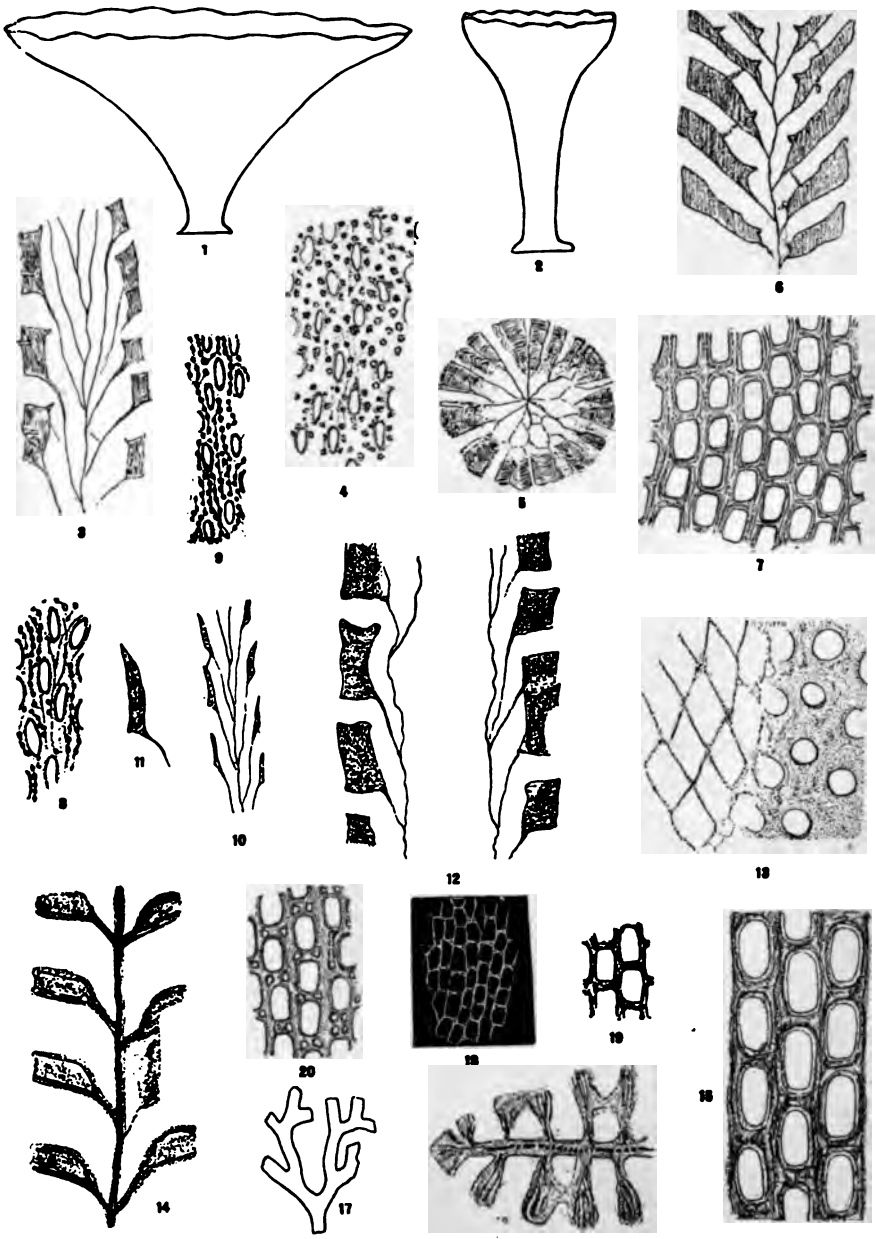
[See also Pl. XXIV, figs. 28-30.]

12. A vertical section, × 20, with the opposite sides brought closer together than in the specimen.
13. A tangential section, × 20, passing through both mature and immature regions and bringing out especially the shape of the primitive zoœcia.
Rochester shale, Lockport, N. Y.

Pachydictya crassa (Hall). (Page 57.)

[See also Pl. XVIII, figs. 11, 12.]

14, 15. Vertical and tangential sections, × 20, illustrating the internal structure of the Rochester form.
16. Portion of a transverse section, × 20, introduced to show the mesial tubuli.
Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE.

Phænopora fimbriata canadensis n. var. (Page 55.)

FIG. 17. Outline of the most complete zoarium seen, natural size.
18. Surface of same, × 8.
19. Tangential section, × 20, showing the two small pores at the end of the zoœcia. Rochester shale, Grimsby, Ontario.

Phænopora fimbriata James. (Page 55.)

20. Portion of a tangential section, × 20, introduced for comparison with fig. 19. Clinton limestone, Dayton, Ohio.

PLATE XXII.

PLATE XXII.

Lichenalia concentrica Hall. (Page 61.)

[See also Pl. XXVI, figs. 7-10.]

FIG. 1. A tangential section, × 6, passing close to the surface of the zoarium and cutting one of the meandering canals.

2. Portion of a tangential section, × 20, cutting the high anterior end of the peristome and a few of the connecting walls.

3. A tangential section, × 20, passing through a lower portion of the zoarium than in fig. 2. The lower portion of the figure illustrates the zoœcia and mesopore-like structures of the mature region, the middle portion, the oblong or rectangular shape of the zoœcia in the immature zone, while in the upper part of the drawing are shown portions of the concentric rings of the epitheca.

4. A portion of a tangential section, × 20, illustrating the nature of the walls of the mesopore spaces.

5. A vertical section, × 20, illustrating the following characters: *z*, the zoœcia; *c*, one of the canals, covered above; *u b*, undulating base of zoarium; *w*, walls forming the mesopore-like spaces; *p*, the extremely high posterior portion of the peristome; *a*, the low anterior portion of the peristome; and *p'*, a posterior portion of the peristome cut obliquely.

6. A more diagrammatic vertical section, × 20, showing especially the low and high portions of the peristome and the walls of the interzoœcial spaces.

Rochester shale, Lockport, N. Y.

Stictotrypa punctipora (Hall). (Page 61.)

[See also Pl. XXIV, figs. 26, 27.]

7. A nearly complete zoarium, natural size, illustrating the usual method of growth.

8. A portion of the surface of the same, × 20, showing the characteristic notch or cleft in the anterior part of the peristome.

Rochester shale, Grimsby, Ontario.

9. A portion of a tangential section, × 20, passing through both mature and immature regions and illustrating especially the rhomboidal shape of the immature zoœcia.

10. A tangential section through the mature region, × 20.

11. A vertical section, × 20.

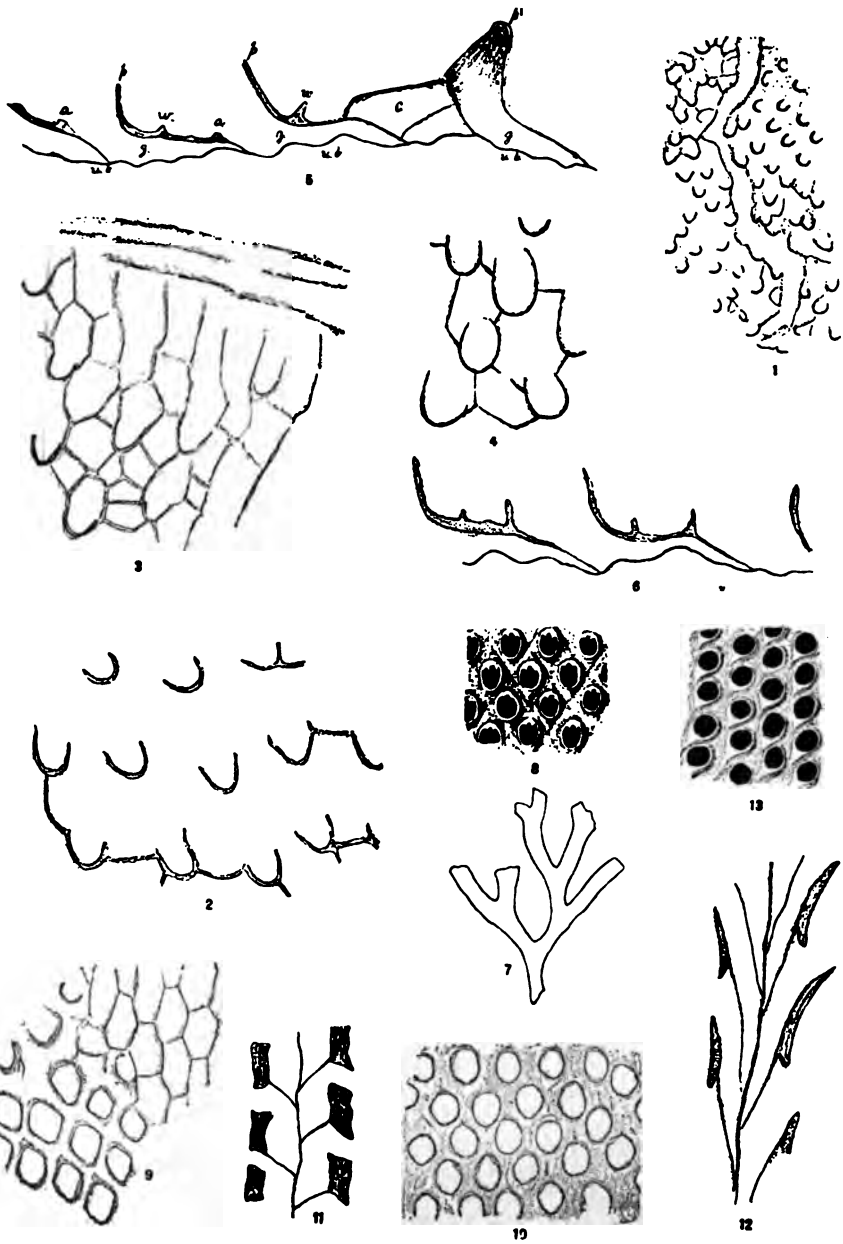
Rochester shale, Lockport, N. Y.

Rhinopora curvata Ringueberg. (Page 60.)

12. A vertical section, × 20, illustrating the bifoliate growth and other characters.

13. Surface of a typical example, × 8.

Rochester shale, Grimsby, Ontario.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE XXIII.

PLATE XXIII.

Pseudohornera diffusa (Hall). (Page 50.)

[See also Pl. XVIII, figs. 6–9.]

FIG. 1. Transverse section of a branch, × 18, showing central lamina.
2. Tangential section, × 18.
3. Vertical section, × 18, showing thick basal plate, the form of the zoœcia, and the abortive cells beneath the central lamina.
Rochester shale, Lockport, N. Y.

Diploclema sparsum (Hall). (Page 17.)

[See also Pl. V, figs. 6, 7.]

4. Tangential section, ×18, cutting the zoœcia at varying levels between the apertures and the median line.
5, 6. Two transverse sections, × 30, showing the central lamina.
Rochester shale, Lockport, N. Y.

Rhinopora verrucosa Hall. (Introduced for comparison.)

7. Fragment, natural size, showing the covered canals.
8. A fragment in which the canals are apparently absent. This specimen closely resembles the zoarium of *Rhinopora curvata*.
9. Enlargement of fig. 8, showing the arrangement of the zoœcia.
Clinton formation, Flamborough Head, Canada.

Cœloclema cavernosa n. sp. (Page 21.)

10. A zoarium, × 1.5, showing the utricular form of growth.
11. A still further enlargement of the same specimen, exhibiting the arrangement of the zoœcia.
12. A vertical section, × 20, through one of the sides of the zoarium.
13. Tangential section, × 20.
Rochester shale, Lockport, N. Y.

Fistulipora tuberculosa Hall. (Page 23.)

[See also Pl. VII, figs. 11–15; Pl. VIII, figs. 7, 8.]

14. A characteristic specimen, × 2, showing the usual utricular method of growth.
Rochester shale, Lockport, N. Y.

Fistulipora crustula n. sp. (Page 24.)

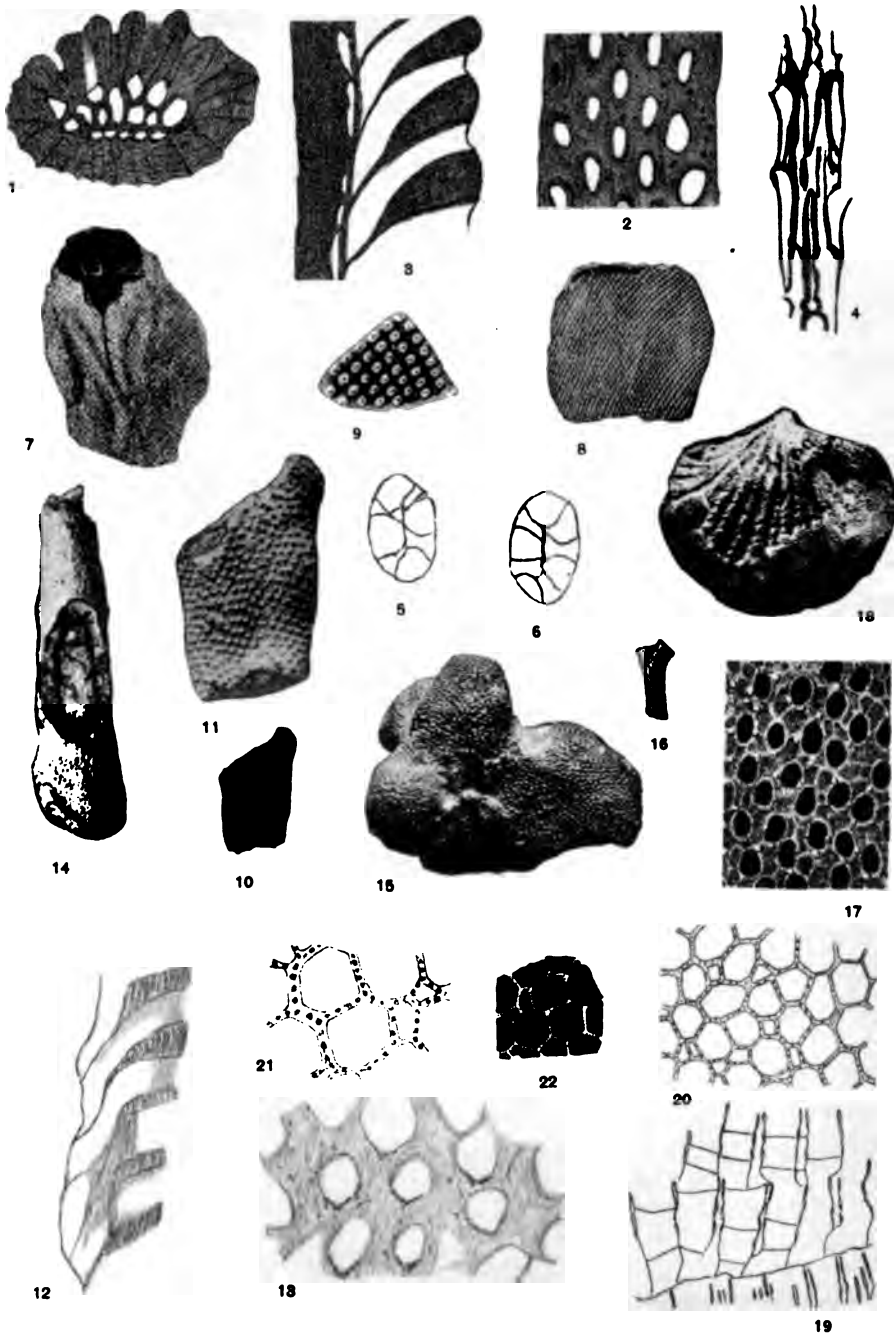
[See also Pl. VII, figs. 7–10; Pl. VIII, figs. 16, 17.]

15. A zoarium, × 2.
Rochester shale, Lockport, N. Y.

Trematopora whitfieldi Ulrich. (Page 44.)

[See also Pl. XXVII, figs. 16, 17.]

16. A fragment, natural size.
17. Surface of same, × 18.
Waldron shale, Waldron, Ind.



BRYOZOA OF THE ROCHESTER SHALE

Lioclema multiporum n. sp. (Page 34.)

[See also Pl. XI, figs. 4-6; Pl. XXVII, fig. 20.]

FIG. 18. A zoarium, × 2, incrusting an *Atrypa*.
Rochester shale, Lockport, N. Y.

Lioclema peculiare n. sp. (Page 35.)

[See also Pl. XXV, fig. 13.]

19. A vertical section, × 20, showing two layers of zoœcia.
20. Tangential section, × 20, exhibiting the many small acanthopores.
21. Several zoœcia and mesopores, × 35, showing the wall structure.
22. Surface of one of the types, × 20.
Rochester shale, Lockport, N. Y.

Figs. 1 to 4 are copied from Ulrich, Geological Survey of Illinois, VIII; 7 to 9 from Hall, Natural History of New York, Paleontology II; 16 and 17 from Ulrich, American Paleozoic Bryozoa.

PLATE XXIV.

PLATE XXIV.

[Unless otherwise stated, all the figures on this plate are copied from Hall, Nat. Hist. New York, Pal. II, 1852.]

Nicholsonella florida (Hall). (Page 38.)

[See also Pl. XIV, figs. 10, 11.]

FIGS. 1, 2. Zoaria enlarged and natural size respectively. In upper half of fig. 1 the floriform apertures are shown while a species of *Lioclema* incrusts a portion of the lower half.
Rochester shale, Lockport, N. Y.

Eridotrypa striata (Hall). (Page 32.)

[See also Pl. XII, figs. 4-6; Pl. XXV, fig. 14.]

3, 4. Enlarged and natural-size views of the basal part of a zoarium.
5. A portion of fig. 3 enlarged to show the striated appearance of the zoœcia toward the base.
6. A fragment of a zoarium, natural size.
Rochester shale, Lockport, N. Y.

Acanthoclema asperum (Hall). (Page 58.)

[See also Pl. XXI, figs. 3-5; Pl. XXV, figs. 17-20.]

7, 8. Three fragments of zoaria, natural size.
9. A portion of fig. 7 enlarged, showing the numerous small acanthopores indenting the elongate-oval zoœcia.
Rochester shale, Lockport, N. Y.

Batostomella granulifera (Hall). (Page 28.)

[See also Pl. XIII, figs. 1-5; Pl. XXV, figs. 11, 12.]

10. Fragment of a zoarium, natural size, showing the usual growth.
11. Surface of a fragment, enlarged.
Rochester shale, Lockport, N, Y.

Bythopora spinulosa (Hall). (Page 29.)

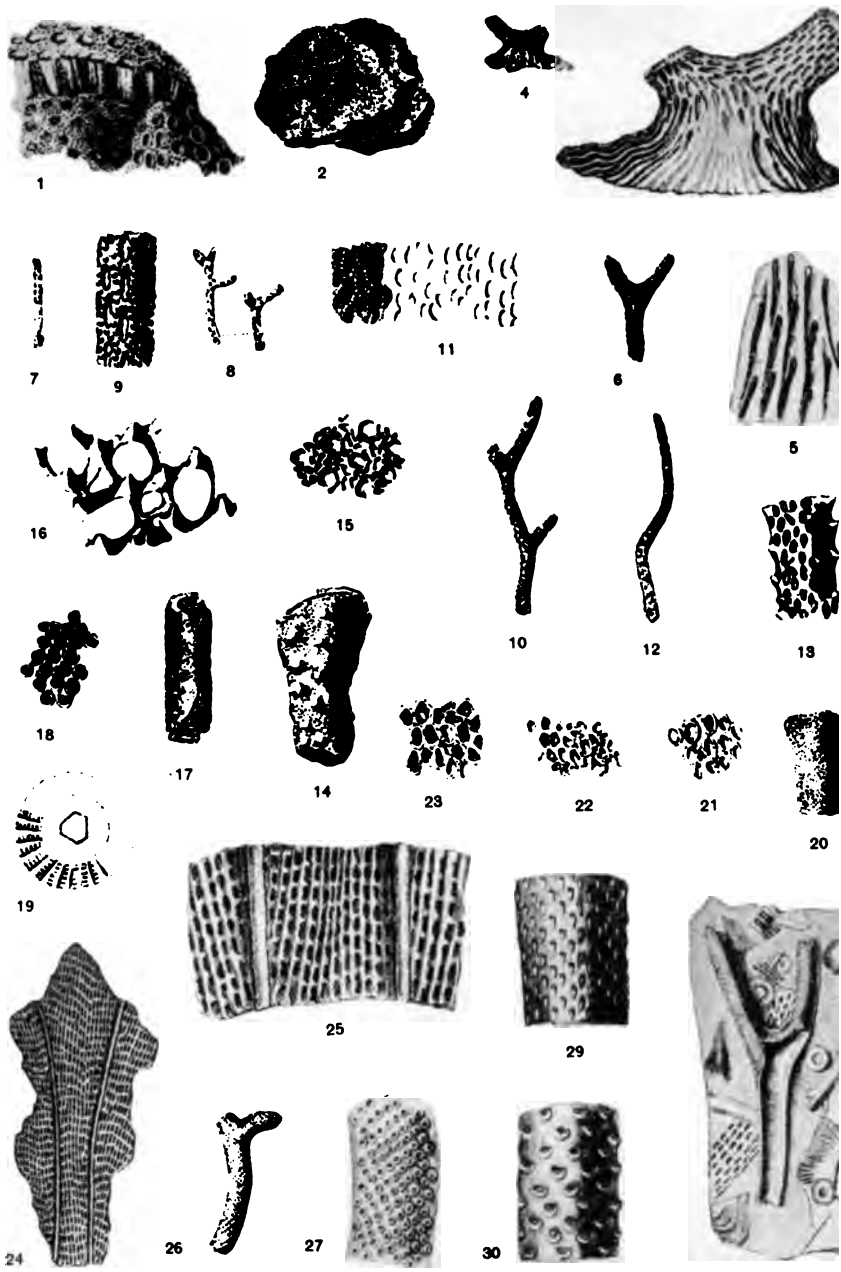
[See also Pl. XIII, figs. 6, 7.]

12. A fragment, natural size, rather more robust than usual.
13. Surface of same enlarged, showing the sharp spines.
Rochester shale, Lockport, N. Y.

Lioclema asperum (Hall). (Page 32.)

[See also Pl. XI, figs. 1-3.]

14. An undulating expansion of this species, natural size.
15, 16. Two enlargements of the surface, exhibiting the numerous mesopores and large acanthopores.
Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE

HELIOTYPE CO., BOSTON

Idiotrypa punctata (Hall). (Page 40.)

[See also Pl. XVII, figs. 4-10.]

FIG. 17. View of Hall's type, natural size, growing about a crinoid column.
18. Surface of same, enlarged.
19. View of a transverse section of the type.
Rochester shale, Lockport, N. Y.

Eridotrypa solida (Hall). (Page 30.)

[See also Pl. XII, figs. 7-9; Pl. XXV, fig. 16.]

20. A small fragment, natural size.
21, 22, 23. Three views of the surface of a zoarium, enlarged.
Rochester shale, Lockport, N. Y.

Ptiloporella nervata (Nicholson). (Page 51.)

[See also Pl. XXVI, figs. 5, 6.]

24, 25. Natural size and enlarged views of the noncelluliferous face. (After Nicholson, Geol. Survey Ohio, Pal. II, Pl. XXV, figs. 11, 11a.
Niagara limestone, Cedarville, Ohio.

Stictotrypa punctipora (Hall). (Page 61.)

[See also Pl. XXII, figs. 7-11.]

26, 27. Natural size and enlarged views of a fragment showing the arrangement and shape of the zoœcia.
Rochester shale, Lockport, N. Y.

Diamesopora dichotoma (Hall). (Page 62.)

[See also Pl. XXI, figs. 12, 13.]

28. Fragment of a zoarium showing the characteristic hollow stems.
29, 30. Two views of the surface, enlarged.
Rochester shale, Lockport, N. Y.

PLATE XXV.

PLATE XXV.

Eridotrypa nodulosa n. sp. (Page 30.)

[See also Pl. XI, figs. 14, 15.]

FIGS. 1, 2, 3. Three fragments, × 2, illustrating the variation in the shape of the tubercles.
Rochester shale, Lockport, N. Y.

Diplotrypa walkeri n. sp. (Page 47.)

[See also Pl. XIV, figs. 1-5.]

4. An average complete zoarium of this species, × 2.
Rochester shale, Grimsby, Ontario.

Lioclemella maccombi n. sp. (Page 36.)

[See also Pl. XI, figs. 7-10.]

5, 6, 7. Three nearly complete zoaria, × 2, showing the unbranched and basally pointed features.
Rochester shale, Lockport, N. Y.

Trematopora tuberculosa (Hall). (Page 43.)

[See also Pl. XIII, figs. 15, 16; Pl. XVII, figs. 1-3.]

8. A fragment of a zoarium, × 2, showing the usual conspicuous tubercles.
Rochester shale, Lockport, N. Y.

Lioclema ramulosum n. sp. (Page 35.)

[See also Pl. XI, figs. 11-13.]

9, 10. Two fragments, × 2, illustrating the usual characters of the species.
Rochester shale, Lockport, N. Y.

Batostomella granulifera (Hall). (Page 28.)

[See also Pl. XIII, figs. 1-5; Pl. XXIV, figs. 10, 11.]

11, 12. Two fragmentary examples, × 2.
Rochester shale, Lockport, N. Y.

Lioclema peculiare n. sp. (Page 35.)

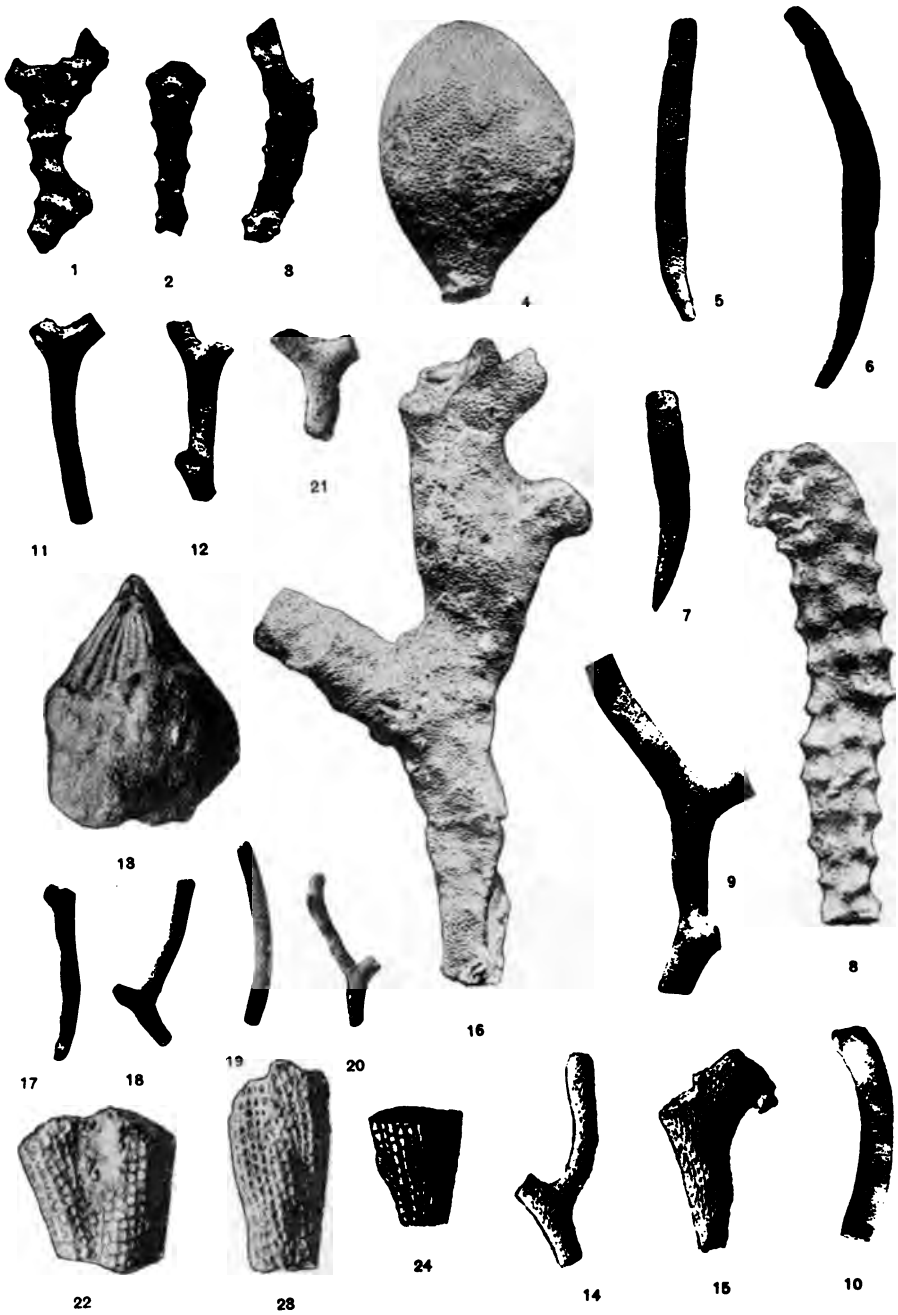
[See also Pl. XXIII, figs. 19-22.]

13. A zoarium incrusting a *Rhynchotreta*, × 2.
Rochester shale, Lockport, N. Y.

Eridotrypa striata (Hall). (Page 32.)

[See also Pl. XII, figs. 4-6; Pl. XXIV, figs. 3-6.]

14. A fragment, × 2, introduced for comparison with fig. 15.
Rochester shale, Lockport, N. Y.



BRYOZOA OF THE ROCHESTER SHALE

Eridotrypa spinosa n. sp. (Page 29.)

[See also Pl. XII, figs. 1-3.]

FIG. 15. A fragment, × 2, showing the larger size of the branch and zoœcia distinguishing the species from *E. striata*.
Rochester shale, Rochester, N. Y.

Eridotrypa solida (Hall). (Page 30.)

[See also Pl. XII, figs. 7-9; Pl. XXIV, figs. 20-23.]

16. Portion of a zoarium, × 2.
Rochester shale, Lockport, N. Y.

Acanthoclema asperum (Hall). (Page 58.)

[See also Pl. XXI, figs. 3-5; Pl. XXIV, figs. 7-9.]

17-20. Four fragments, × 2, illustrating the usual characters of specimens found in washings.
Rochester shale, Lockport, N. Y.

Rhombotrypa spinulifera n. sp. (Page 37.)

[See also Pl. X, figs. 13-16.]

21. Portion of a zoarium, × 2, illustrating the usual shape of the fragments found.
Rochester shale, Rochester, N. Y.

Loculipora ulrichi n. sp. (Page 53.)

[See also Pl. XXI, fig. 2.]

22-24. Three fragments of the basal portions of zoaria, × 2.
Rochester shale, Grimsby, Ontario.

PLATE XXVI.

PLATE XXVI.

Eridotrypa similis n. sp. (Page 31.)

[See also Pl. XII, figs. 10–14.]

FIGS. 1, 2. Two nearly complete zoaria, × 1.3.
Rochester shale, Grimsby, Ontario.

Callopora magnopora Foerste. (Page 42.)

[See also Pl. XV, figs. 1–8.]

3. Fragment of a zoarium, × 1.3, showing the thickness of the branch.
Rochester shale, Grimsby, Ontario.

Lioclema explanatum n. sp. (Page 33.)

[See also Pl. XIII, figs. 8–10.]

4. Basal view of a complete zoarium, × 1.3, showing the undulating epitheca.
Rochester shale, Rochester, N. Y.

Ptiloporella nervata (Nicholson). (Page 51.)

[See also Pl. XXIV, figs. 24, 25.]

5, 6. Noncelluliferous and celluliferous faces of two zoaria, × 1.3, exhibiting the prominent primary branches.
Rochester shale, Grimsby, Ontario.

Lichenalia concentrica Hall. (Page 61.)

[See also Pl. XXII, figs. 1–6.]

7, 8. Views of two young examples, natural size, showing the subcircular laminar zoœcia.

9. A portion of a zoarium, natural size, exhibiting the characteristic concentric undulations of the epitheca.

10. A portion of the epithecated side, enlarged.
(Figs. 7 to 10 after Hall, Nat. Hist. New York, Pal. II, 1852, pl. 40E.)
Rochester shale, Lockport, N. Y.

Monotrypa benjamini n. sp. (Page 46.)

[See also Pl. XVI, figs. 6–9.]

11. A zoarium, × 3, split through its length to show the characteristic crenulated zoœcial walls.
Rochester shale, Rochester, N. Y.

Callopora elegantula Hall. (Page 41.)

[See also Pl. XVII, figs. 11–15.]

12. Fragment of a zoarium, × 3, exhibiting the usual arrangement of zoœcia and mesopores. Many of the zoœcia are closed by opercula.
Rochester shale, Rochester, N. Y.

BRYOZOA OF THE ROCHESTER SHALE

PLATE XXVII.

Thamniscus dichotomus (Hall). (Page 54.)

[See also Pl. XVIII, figs. 17-19.].

FIG. 1. Surface view of a young example, × 20, showing the separating ridges.
2. Portion of the surface of a more mature example, × 20, in which the ridges are less marked and the granules more pronounced.
3. View of the noncelluliferous side of a young example, × 20, in which the characteristic granulose striæ are well exhibited.
4. Celluliferous and noncelluliferous faces of two zoaria, natural size, exhibiting the characteristic dichotomous branching.
5. Tangential section, × 20, passing close to the surface of the celluliferous side.
6, 7. Two vertical sections, × 20.
Rochester shale, Grimsby, Ontario.

Phænopora ensiformis Hall. (Page 55.)

8, 9. Tangential and vertical sections, respectively, × 20, showing the internal structure.
Rochester shale, Grimsby, Ontario.

Tæniodictya schucherti n. sp. (Page 57.)

10. Vertical section, × 20.
11. Tangential section, × 20, in which the zoœcia have thickened walls and are arranged less regularly than usual.
12. Portion of tangential section, × 20, showing the usual arrangement of the zoœcia.
13. Outline sketch, natural size, of the type of the species.
Rochester shale, Grimsby, Ontario.

Trematopora spiculata Hall. (Page 45.)

14, 15. Tangential and vertical sections, respectively, × 20.
Rochester shale, Lockport, N. Y.

Trematopora whitfieldi Ulrich. (Page 44.)

[See also Pl. XXIII, figs. 16, 17.]

16, 17. Vertical and tangential sections, × 20.
Waldron shale, Waldron, Ind.

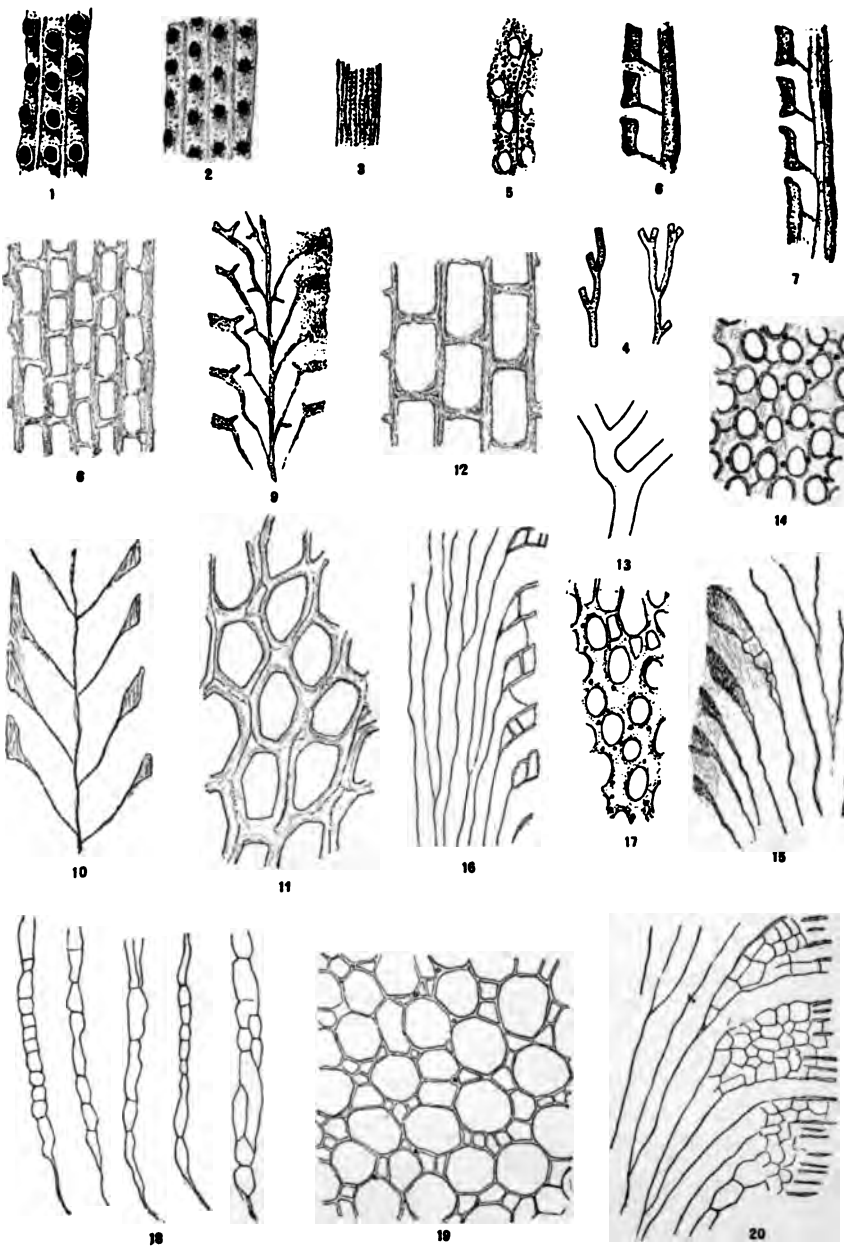
Lioclema globulare n. sp. (Page 35.)

18. Vertical section, × 20, showing the absence of diaphragms in the zoœcia, and the irregular tabulation of the mesopores.
19. Tangential section, × 20, exhibiting the thin-walled zoœcia and few acanthopores.
Rochester shale, Lockport, N. Y.

Lioclema multiporum n. sp. (Page 34.)

[See also Pl. XI, figs. 4 6; Pl. XXIII, fig. 18.]

20. A vertical section, 20, of the subramose form.
Rochester shale, Rochester, N. Y.



BRYOZOA OF THE ROCHESTER SHALE.

PLATE XXVIII.

PLATE XXVIII.

Slab about two-thirds natural size, showing abundance of bryozoan remains upon surface. The limestone layer, of which this slab is a portion, is made up almost entirely of bryozoa. Rochester shale, pulp mill along Erie Canal, Lockport, N. Y.

BRYOZOA OF THE ROCHESTER SHALE

PLATE XXIX.

PLATE XXIX.

A portion of the surface of slab figured on Pl. XXVIII magnified about one and a half times. In this particular specimen the solid and hollow ramose forms are particularly abundant.

Rochester shale, pulp mill along Erie Canal, Lockport, N. Y.

CHESTER SHALE

PLATE XXX.

PLATE XXX.

View of a fragment of a thin limestone layer, magnified two diameters. In this layer the slender ramose species such as *Diploclema sparsum*, *Nematopora minuta*, and *Acanthoclema asperum* are particularly abundant.

Rochester shale, near locks of Erie Canal, Lockport, N. Y.

BRYOZOA OF THE ROCHESTER SHALE

PLATE XXXI.

PLATE XXXI.

A portion of the surface of a slab, magnified about two diameters, showing more numerous fenestellids than on the other specimens figured. The ramose specimen in the central part of the plate is a typical example of *Dnamesopora dichotoma*.

Rochester shale, Niagara Gorge, New York.

BRYOZOA OF THE ROCHESTER SHALE

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[Names in italic are of synonyms; figures in black-face type show location of descriptions; figures in italic refer to illustrations.]

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RECONNAISSANCE

OF SOME

GOLD AND TIN DEPOSITS OF THE SOUTHERN APPALACHIANS

BY

L. C. GRATON

WITH

NOTES ON THE DAHLONEGA MINES

BY

WALDEMAR LINDGREN

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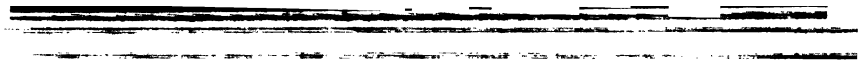

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RECONNAISSANCE OF SOME GOLD AND TIN DEPOSITS OF THE SOUTHERN APPALACHIANS.

By L. C. GRATON.

INTRODUCTION.

FIELD WORK AND ACKNOWLEDGMENTS.

That part of the Carolinas which lies immediately to the southeast of the Blue Ridge, in what is known as the Piedmont region, has long been of both scientific and commercial importance, largely on account of the variety and abundance of its minerals. In 1904 the writer was detailed to make a brief preliminary study of the mineral resources of a portion of this area, under the direction of Mr. Waldemar Lindgren. The work began October 5 and ended November 25, being thus favored by the delightful autumn of the South. Near the close of October the writer enjoyed the advantage of Mr. Lindgren's active supervision in the field for about five days and was also privileged to accompany him on a trip of a few days to the Dahlonega gold region of Georgia, where interesting comparisons with the Carolina deposits could be made. Mr. Lindgren kindly consented to publish in this bulletin a brief description of the Dahlonega mines. A few hours were spent in November at the Cash tin mine, in Rockbridge County, Va., to ascertain if this deposit is related to those of the Carolina belt. Early in May, 1905, the writer made a three days' visit to the tin belt to learn of later developments.

During the course of the field work assistance was rendered and information furnished by many persons residing in the area traversed. Especial thanks are due to Mr. E. A. Thies, manager of the Haile mine; Mr. O. J. Thies, manager of the Blackmon mine; Mr. J. L. Daniels, superintendent of the Ross mine; Mr. John F. Jones, of Blacksburg, and Messrs. M. M. Carpenter and A. R. Rudisill, of Kings Mountain. The writer is glad of this opportunity to acknowledge his indebtedness to Mr. Lindgren, whose constant and inspiring interest in the work and willing criticism and suggestion have been of great value and assistance.

SCOPE OF REPORT.

A complete study of the area would have resulted in a thorough understanding of the general geology, as well as in detailed information regarding the mineral resources. But several things conspired to make it very difficult to obtain an accurate and comprehensive idea of the geology. The area to be covered in the time at the writer's disposal made it necessary to confine effort almost entirely to visiting mines and mineral localities. No topographic or other thoroughly reliable maps of this particular district have been published—a lack which made accurate locations of particular points impossible and reduced the amount of ground which could be covered. Finally, decomposition of the rocks is so profound that it is, in general, only by careful and repeated examination of the altered products and extended search for exposures of fresh material that safe conclusions as to lithology can be reached.

The following report, therefore, deals principally with the mineral deposits, but the broader geology will be described and its bearing on the economic features indicated so far as possible.

LITERATURE.

This portion of the United States has been long settled and was one of the earliest mineral regions in the country to become of economic importance. It has, therefore, attracted much attention from geologists, particularly before the civil war, and many of the leading scientists of their time have studied and described it. It is interesting to note that the North Carolina Geological Survey, established in 1824, with Prof. Denison Olmsted at its head, was the first organized effort of the kind on this continent. South Carolina followed next, in 1826, with its survey under Vanuxem. Through these surveys Tuomey, Lieber, Ebenezer Emmons, Kerr, Hanna, and Nitz made contributions to the geology of the Carolinas that have become well known.

The preliminary nature of this report does not properly admit the inclusion of a complete bibliography of this general region, but throughout the report there are many references to articles or portions of works which deal with the area here described.

GEOGRAPHY.

LOCATION AND GENERAL FEATURES.

The area under consideration lies between meridians 80° and 82° west and parallels 34° 30′ and 35° 30′ north. It centers at about the middle of the North Carolina-South Carolina boundary line and includes parts of Cleveland, Lincoln, Gaston, and Union counties in

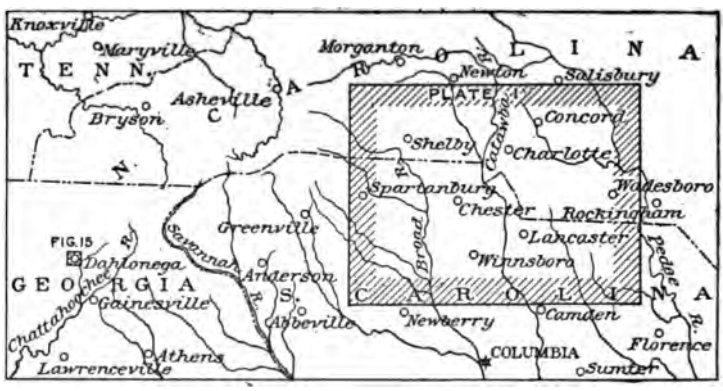


FIG. 1.—Index map showing location of area.

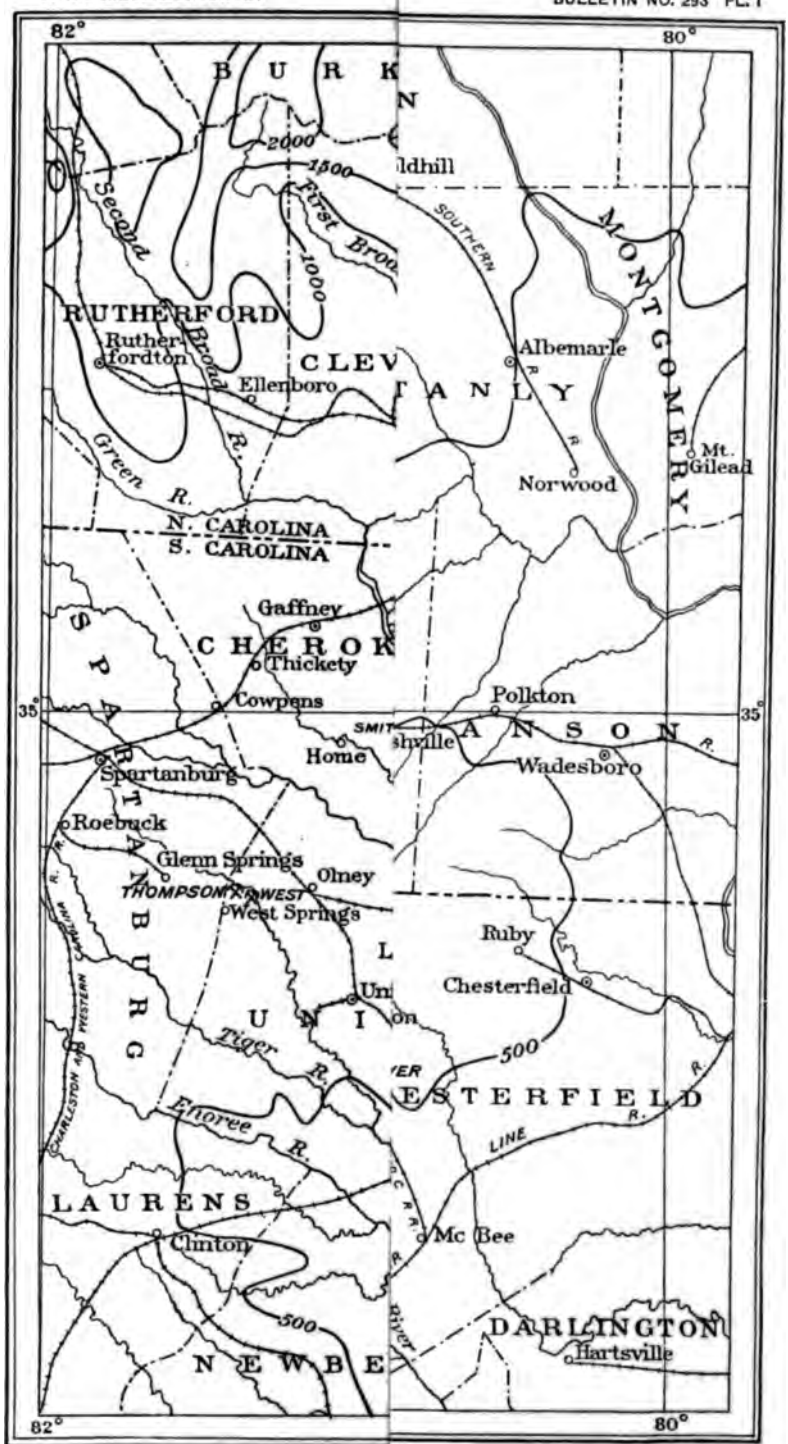
North Carolina, and of Union, Cherokee, York, Lancaster, and Chesterfield counties in South Carolina. (See fig. 1.) Outside of the many small towns, the country is rather thinly populated, but roads are numerous and generally good. Transportation is facilitated by a number of railroads. Two branches each of the Southern Railway and the Seaboard Air Line and one line each of the Carolina and Northwestern, the Lancaster and Chester, and the Charlotte, Monroe and Columbia Railroads cross the district.

TOPOGRAPHY.

GENERAL OUTLINE.

The topography of this area is so largely dependent on its geology and on the geology and topography of the surrounding region that it will be of advantage to consider the latter features briefly before endeavoring to describe the local topography.

The territory embraced by the Eastern States from Pennsylvania to Alabama is commonly divided, on the joint grounds of topography and geology, into three zones trending northeast and southwest and approximately parallel.


82°
80°
BURKE
2000
1500
1000
Second
First Broad
SOUTHERN
MONTGOMERY
RUTHERFORD
Rutherfordton
Broad R.
CLEVELAND
Albemarle
Ellenboro
Norwood
Mt. Gilead
Green R.
N. CAROLINA
S. CAROLINA
Gaffney
CHEROKEE
Thickety
SPARTANBURG
Cowpens
Pollkton
35°
ANSON
Wadesboro
Spartanburg
Roebuck
Glenn Springs
Olney
THOMPSONVILLE
West Springs
Ruby
Chesterfield
Union
Tiger R.
ESTERFIELD
Enoree R.
LAURENS
Clinton
Mc Bee
500
NEWBERRY
DARLINGTON
Hartsville
Pee Dee River
LINE

On the northwest is the mountain belt of the Appalachian system, made up of sedimentary and accompanying igneous rocks, much folded, metamorphosed, and dissected. For most of the distance the Blue Ridge is the easternmost range of this mountain zone.

Skirting the eastern flank of the Appalachians lies the Piedmont Plateau. Although composed of older rocks, it is structurally similar to the mountains; but it is now so worn down by erosion that, viewed broadly, its surface is a plain which bevels the edges of the upturned strata composing it.

On the southeast the Piedmont rocks are concealed by the overlying unconsolidated sediments of the Coastal Plain.

The particular area which is the subject of this study forms a part of the Piedmont Plateau and extends on the east approximately to the boundary of the Coastal Plain. Its geological structure conforms with that of the mountains and of the other portions of the Piedmont belt; the rocks are much folded, usually dip at large angles, and almost invariably have a northeasterly strike.

RELIEF.

DESCRIPTION.

Standing upon any slight elevation the observer remarks the generally flat character of the country. The level sky line is almost unbroken until the foot of the Blue Ridge is reached. This fact is indicated by the map (Pl. I), on which this area is represented almost entirely between the 500- and 1,000-foot contour lines. For this reason features of relief which would otherwise be of small significance become conspicuous and are often assigned an undue importance. Almost every elevation which may be seen at a distance of more than a mile or two is dignified by the name mountain.

The most noticeable topographic feature is a chain of disconnected ridges extending southwestward across Lincoln, Gaston, and Cherokee counties and part of Cleveland and York counties. Crowders, Kings, Whitaker, Draytonville,[a] and Thickety mountains are the culminations of the ridges of this chain, which is commonly designated as the Kings Mountain Range, both because of the prominence of that elevation and because of the historical significance[b] attached to the name.

Although rising only a few hundred feet above the surrounding plain, these hills form noticeable landmarks for miles around. Kings Mountain, which is the highest, is said to be about 1,700 feet above sea level, and its summit is probably 600 to 700 feet above the plateau at its base. Crowders Mountain is somewhat lower, and the other hills are much less prominent. All these hills rise rather abruptly from the plain, and some of them, as Kings Mountain, are bounded on one or more sides by steep cliffs.

With a few unimportant exceptions, such as Henry Knob and Nannies Mountain, in York County, the topography is otherwise diversified only by depressions below the general level of the plain. These depressions are the valleys of present or past streams and give a rolling or undulating surface to the country. The monotony of the ordinary plain is thus relieved and a pleasing aspect given to the landscape.

DEVELOPMENT.

The prevalent explanation of the origin of the Piedmont topography may be summarized as follows: It is supposed that the Piedmont Plateau was once a mountain region, much like the present Appalachians. During long intervals, in which this region was subjected to erosion, very little elevation or depression took place. This constant stand of the land gave the rivers opportunity to lower the surface gradually toward sea level. By a continuation of this process the greater portion of the region was degraded to a very slightly undulating plain, called a peneplain, which sloped gently toward the ocean. The streams

[a] Sometimes called Gelky's Gelkey's, or Gilkey's.

[b] A stone shaft marks the site of the battle of Kings Mountain, one of the decisive engagements of the Revolutionary war, fought October 7, 1780.

then occupied extremely shallow and broad valleys and flowed sluggishly, with little degrading power. Areas of rock particularly resistant to the agencies of denudation partially withstood this otherwise general planing down and remained as monadnocks, somewhat elevated above the general surface of the peneplain.

Before these last remnants could be reduced to the common level the whole region was elevated to approximately its present height. With their grade thus increased, the streams took on new vigor and again began active cutting. Up to the present time they have been unable to remove these conspicuous residuals of the former topography, but have produced the other variations in the surface as it appears to-day.

The monadnocks of the area concerned in this report are the hills above described—Kings, Crowders, Draytonville,[a] and other mountains. All these eminences are made up of hard and resistant rock, in most cases quartzite. To this fact, as has been shown, they owe their commanding position.

DRAINAGE.

DESCRIPTION.

A well-developed system of drainage is established in this region about three principal channels—Lynchs, Catawba, and Broad rivers. All these rivers flow across the area in a direction slightly east of south, turn more to the southeast on the Coastal Plain, and empty into the Atlantic.

On the east Lynchs River, formerly called Lynchs Creek, rises in the southern part of Union County, N. C., and forms the boundary between Lancaster and Chesterfield counties, S. C. It flows into the Pedee, which is the lower part of Yadkin River.

Catawba River drains the central part of the area. Rising in the western part of McDowell County, N. C., it takes a course slightly north of east to the northwest corner of Catawba County, and then flows almost due south, forming the eastern boundary of Lincoln and Gaston counties. In South Carolina it crosses York County and separates Chester and Lancaster counties. It there becomes known as Wateree River, and farther south joins the Congaree to form Santee River, which continues to the coast. Little Catawba River, one of its principal tributaries, rises in the northern part of Catawba County, crosses Lincoln and Gaston counties, and reaches the Catawba just north of the State line.

Broad River heads in the western part of Rutherford County, N. C., flows southeastward nearly to the State line, and then turns almost due south, crossing part of Cherokee County and forming the eastern boundary of Union County, S. C. At the edge of the Piedmont Plateau it unites with the Saluda to form the Congaree, which in turn joins the Wateree to form the Santee. Two tributaries within the area are of sufficient size to be mentioned, viz: Broad River rises in the northern part of Cleveland County, flows southward and empties into Broad River just north of the State line. Pacolet River heads in the northeastern part of Spartanburg County, forms the southern limit of Cherokee County, and reaches Broad River at the corner of Cherokee, York, Chester, and Union counties, S. C.

Each of these rivers has numerous minor tributaries, of which the greater number flow in a southeasterly direction.

Nearly all the streams are rather swift and flow over innumerable rapids, commonly called shoals, and at some places over considerable falls, thus furnishing power for many mills. The water is generally yellow and muddy, owing to the large amount of material held in suspension. The valleys are, as a rule, not deep, but have rather steep sides. Most of the streams, particularly the upper tributaries, have noticeably straight courses.

DEVELOPMENT.

Only a glance at a large-scale map of the area and of the surrounding region is needed to show that the general direction of the streams is southeasterly and that their disposition corresponds rather closely with the drainage that would be expected if a plain, tilted in

[a] Cf. Tuomey, M., Geology of South Carolina, 1848, p. 101.

that direction and composed of homogeneous material, had been exposed for a considerable time to erosion. It is known that the elevated peneplain slopes to the southeast, and the drainage of this area is therefore largely consequent—the result of the initial slope of the plain. But it has been shown that this plateau is composed of rock beds tipped on edge and striking northeasterly. These various beds of rock are of dissimilar composition, and hence possess different degrees of hardness and resistance to corrosion and corrasion.

The natural result when streams flowing down a slope cross a discordant structure is adjustment to that structure, finally causing them to flow along the strike of the rocks. When such a result is not reached, as it is not in the present case, other conditions must have entered.

The explanation which first suggests itself is that after planation the Piedmont Plateau was submerged, covered with a layer of sediments, and then elevated to its present stand. Consequent drainage established on its slope would cut through this mantle and be superimposed on the transverse structure of the ancient rocks below. There is, however, no evidence preserved of such a submergence or of such a deposit, and this explanation may therefore be abandoned.

A second explanation involves much the same principles as the first. It has been shown that the region now occupied by the Piedmont Plateau was eroded nearly to base-level. When this process, whose effect gradually lessened, had reduced the land well toward a peneplain, the rate of erosion became so slow that decomposition of the rocks—perhaps aided by the peculiar conditions existing at such a stage [a]—proceeded faster than degradation. That decomposition has actually exceeded denudation is evidenced by the fact that many of the streams have not yet cut down to fresh rock; but the rate at which the streams are now cutting, when compared with that in other regions, is almost certainly greater than that of decomposition—an indication that decomposition could have exceeded denudation only when conditions were different from those at present.

During the interval from the time when decomposition began to proceed faster than its products could be carried away until the streams were finally rejuvenated by uplift, atmospheric alteration of the rocks had opportunity to extend far below the surface of the peneplain. It is probable that all the rocks of the region, including the quartzites (which, as will be seen later, are impure, holding much mica, and hence readily susceptible to disintegration), were, at the surface where decomposition was greatest, reduced to soil. But, under the sluggish action of the streams, which had almost attained base-level, this soil remained in situ and still retained the structure of the rocks from which it had been derived. Here, then, was a layer of soft and relatively unresistant material to serve as a mantle to the hard rocks below. In appearance it possessed a decided structure of its own; in essence it was at the surface almost structureless.

The drainage consequent on the establishment of the present Piedmont slope began to trench this covering of soil and soon incised considerable valleys in it. As the streams wore down the beds of rock more resistant to weathering were discovered and eroded, but, in general, less rapidly than the surrounding beds. In this way the rapids and falls were formed. These barriers tended to divert the streams and adjust them to this newfound structure, but the valley walls already formed held the streams closely to their initial consequent courses. At present a number of streams have cut down to and into solid, fresh rock, to whose structure they show very little adjustment.

Such streams appear to belong in a subdivision of superimposed rivers. They have courses "quite out of accord with the underlying structures on which they have descended," [b] but the relatively thin overlying mass through which they have first cut, instead of being an unconformable deposit, as the usual definition of this class of rivers requires, is the irregularly decomposed zone of the deeper lying rocks.

Other factors have doubtless helped to maintain this unadjusted condition of the streams. The principal one of these is steepness of slope to the southeast—i. e., across the structure.

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[a] Cf. Campbell, M. R., Erosion at base-level: Bull. Geol. Soc. America, vol. 8, 1897, pp. 221-226.
[b] Davis, W. M., Rivers of northern New Jersey: Nat. Geog. Mag., vol. 2, 1890, p. 82.

Although the Piedmont Plateau appears approximately level, its slope is considerable when compared with the average profile of streams in soft material. This slope prevents an overloading of the streams, and consequently, by preventing meandering, induces the fairly straight courses which have already been alluded to in the description. The slope also causes headward cutting of the tributaries, which likewise results in straight courses. Such courses are less easily brought into adjustment with discordant structure than meandering courses.

Some adjustment has, however, taken place, as shown by a number of the smaller, and hence younger, tributaries, whose courses are parallel to the strike of the rocks. Such subsequent tributaries of some of the larger consequent streams have been able in certain instances to capture weaker consequent streams which were perhaps held up by the temporary base-level of a hard rock barrier.

An interesting evidence of the planation of this region is shown on the map, where it is seen that the railroads are enabled to follow the present watersheds or divides, whereas in most regions of equally diversified topography they are forced to follow the more circuitous courses of the stream valleys.

GENERAL GEOLOGY.

DESCRIPTION OF THE ROCKS.

OUTLINE.

The rocks of this area belong to three great classes—igneous, sedimentary, and metamorphic. Sedimentary and igneous rocks of great age have been much contorted and folded. The forces producing and attendant on these movements have extremely metamorphosed the rocks, converting them into schists. Volcanic rocks, mainly represented by bedded tuffs, covered these metamorphosed rocks in places and were themselves subjected to a part of the metamorphosing influences. Into these metamorphic rocks later igneous material has been intruded. Granite is the most abundant of these igneous rocks and the numerous dikes of pegmatite are probably closely connected with it. Diabase dikes cutting all the foregoing rocks are the last representatives of intrusion. On the eastern border of the area the solid rocks are covered by thin beds of sand, which probably belong to the Coastal Plain formations.

METAMORPHIC ROCKS.

The metamorphic rocks of this district have resulted from the action of the tremendous forces of mountain building. They are usually extremely metamorphosed, and may be placed in that perplexing group, the crystalline schists. In many places nearly or quite all traces of their original character have been removed; but here and there the former nature of the rock can be seen, and by comparison and analogy the more altered varieties are correlated. These schistose rocks are derived from both igneous and sedimentary formations.

SCHISTS OF IGNEOUS ORIGIN.

AMPHIBOLITE.

The most common and abundant rock under this head is hornblende schist or amphibolite. In some places, as in central York County, the gradation from this rock into fairly unchanged gabbro can be traced with certainty. It seems probable, however, that much of it has resulted from volcanic as well as from plutonic rocks, for its exact intercalation with the sediments in many places would indicate that it had been in such cases a surface rock, probably occurring as basaltic flows or tuffs. On subjection to shearing and other metamorphosing processes these igneous rocks were foliated and otherwise altered, becoming schistose amphibolite.

These amphibolites are fine-grained rocks, of dark, greenish color, generally possessing a definite structure in one direction, or "grain." In some of them the foliation is suffi-

cient to allow a very easy parting in thin plates. Under the microscope the rocks are found to have a surprisingly large amount of feldspar, in consideration of their very dark color. They are typical "greenstone schists." The feldspar occurs in small, rudely polygonal grains, in many specimens built up zonally, commonly untwinned, and perfectly clear. It belongs mainly to the variety albite, with a less amount of oligoclase. Epidote is often found in abundance, both in irregular interstitial grains and as lath-shaped prisms poikilitically penetrated by other constituents of the rock. Zoisite occurs in a manner similar to epidote and is on the whole more common. These two minerals may occur together and in many cases can be distinguished only in polarized light. Calcite likewise occurs in numerous specimens, in irregular grains and in lath-shaped individuals, and was undoubtedly present when the recrystallization of the rock took place. Calcite is usually not abundant in those specimens which contain much of the calcium silicates epidote and zoisite, or, if it is, it occurs principally in bands or zones in which they are sparingly present. Quartz, either formed by the removal of bases from some of the silicates or introduced by the waters producing metamorphism, perhaps also in part primary, forms mosaics of small clear grains which are distinguishable from albite only in convergent polarized light.

The dark constituent is the typical amphibole of the "greenstone schists" and is probably uralite. It occurs in well-formed prisms and in irregular, elongated grains, but in no case was it seen developed as a pseudomorph after pyroxene. As a rule, it is rather strongly pleochroic in bluish and brownish greens and has a not very strong double refraction.

Black iron ore is generally abundant and is associated particularly with the amphibole. The most common occurrence is in irregular grains, but in some cases it is present as crystals of definite outline, usually too small to be accurately determined as to form, but sometimes showing a pair of predominant parallel faces that give the crystal a flattened appearance and suggests ilmenite. Many of the grains are surrounded by borders of sphene, and in some cases the change to this mineral has been complete. In a few instances a mineral which is probably rutile accompanies the titanite. The iron ore is therefore titaniferous in most or all cases. Small broken grains of zircon are present in a few specimens.

In those specimens which contain considerable calcite, epidote, or zoisite it is not uncommon to find irregular grains, turbid and decomposed but still showing the twin lines, of a moderately calcic plagioclase, usually labradorite. The rocks free from calcite, epidote, and zoisite have in general a cleaner, better-defined appearance than those which are not. It appears probable that the crystallization of these secondary lime-bearing minerals is only an intermediate step in the complete metamorphism of the original rock, the ultimate result being their solution and removal, leaving a rock decidedly less rich in lime than the original.

These amphibolites thus present a typical example of the original metamorphism of a rather basic igneous rock, probably having the composition of a gabbro, with the production of a wholly recrystallized and altered schist.

Rocks of this character are extremely common in the western part of the area examined and probably are the most widely developed variety in that part. In central York County, as has been said, the degree of metamorphism which they have suffered is not so great. There they possess a more granitic texture and pass gradually into gabbros. In the eastern part of the area amphibolites were less commonly observed, although a study of the areal geology might reveal them in abundance.

QUARTZ-SERICITE SCHIST.

Dense, siliceous rocks, usually of rather light gray color, more or less schistose, occur in several portions of the area and may have a considerable extent. A peculiar silvery, mottled luster, frequently seen on the planes of schistosity, has won for these rocks the very suggestive name applied by the miners, "fish-scale slate." The appropriateness of this name is especially apparent when the rocks are wet and viewed by the flickering light of the miner's candle.

In their common development it would be a very difficult matter to determine the nature of the rocks from which these have been derived, but fortunately a clue is given in a few localities, where enough of the original character is preserved to aid in arriving at a fairly definite conclusion.

The least altered of these rocks are well-bedded, fine-grained, and not very much indurated tuffs, made up of irregular fragments of a rock which if massive would have been a porphyry. Broken grains, some of them rounded, of quartz and feldspar, representing original phenocrysts, are embedded in an evenly fine-grained matrix of quartz, feldspar, and mica. The porphyries from which these fragmental rocks were derived therefore correspond to granite porphyry and quartz-monzonite porphyry and were probably related to the porphyries which occur in the vicinity of the Brewer mine in Chesterfield County and the Blackmon mine in Lancaster County.

The quartz appears in many cases to have existed in the massive rock as sharp double pyramids without development of prism faces. The character of the feldspar varies in different localities. In the neighborhood of the Ferguson gold mine, in the northwest corner of York County, for instance, most of the determinable individuals of feldspar appear to belong to the varieties oligoclase and andesine. At the Colossus mine, in the southwestern part of Union County, N. C., microcline is most abundant, while microperthite is rather common. At the Haile mine, in the southern part of Lancaster County, the character of the feldspar could not be determined. Both biotite and muscovite are present, and while it seems probable that the former at least was an original constituent of the rock, the evidence is not conclusive and the mica may have been introduced by the contact metamorphism to which the rock has plainly been subjected. The biotite is present in small ragged flakes, usually exhibiting a parallelism of arrangement and indicating the direction of foliation of the rock. It is of a clear brown, and shows fairly strong absorption and rather strong polarization. In many cases it has been changed to a dirty greenish chlorite. Muscovite is doubtless secondary in all cases, having been derived both from the biotite, by the common but poorly understood process known as bleaching, and from the feldspars by decomposition. In the less foliated rocks it can be seen in process of formation from both these minerals. Compact, fibrous muscovite or sericite occurs commonly in the more schistose rocks and is especially abundant along certain planes which are planes of greatest movement and hence of greatest weakness—in other words, planes of schistosity. It is the silvery sheen of this muscovite, exposed when the rock is cleaved along these planes of fissility, which gives rise to the term "fish-scale slate."

It is possible that these soft tuffs cover a considerable area, but do not outcrop conspicuously, and are in consequence overlooked. The localities where they were found, however, are in the immediate vicinity of gold deposits, and there, owing to their physical make-up, being rather porous and in fine particles, and possibly also to their chemical constitution, they were easily attacked by the mineral-bearing solutions which produced the gold deposits and were very greatly altered. This alteration has been for the most part a silicification with attendant recrystallization. Feldspar, biotite, and sericite have all been attacked and more or less completely replaced by quartz. Since these silicified tuffs are closely connected genetically with the gold deposits which occur in them they are more fully described in the section dealing with gold (pp. 78–79).

These granite-porphyry and quartz-monzonite-porphyry tuffs have been observed in the vicinity of the Haile mine in Lancaster County, the Colossus or Howie mine in Union County, N. C., and the Ferguson mine in York County. They doubtless belong in the group of ancient volcanic rocks whose distribution in the eastern part of North America has been set forth by G. H. Williams.[a]

GNEISS (SCHISTOSE GRANITE)

Much-foliated rocks which show by their texture and composition that they were origially granites are found in isolated localities throughout the area. They are usually of rather

[a] Jour. Geol., vol. 2, 1894, pp. 28 et seq.

fine grain and light color and exhibit by the position of the dark biotite flakes a decided foliation. When greatly weathered it is not always possible to distinguish them from granite.

Viewed under the microscope quartz is seen to be fairly plentiful and shows crushing and strain shadows. Microcline is very abundant in many specimens, intergrown micropegmatitically with the quartz. A little plagioclase is present and probably is albite. Small broken plates of brown biotite and of muscovite occur somewhat sparingly. Fragments of apatite crystals are sometimes seen and more rarely broken grains of zircon. Crushing seems to have taken place, especially along certain zones.

The gneisses are most common along the Kings Mountain Range, but probably occur also at places in the eastern part of the area, as in the western part of Chesterfield County.

As is shown on page 20, it is probable that these gneisses have a close genetic connection with the massive granites.

SCHISTS OF SEDIMENTARY ORIGIN.

QUARTZ SCHIST.

Foliated or schistose rocks made up principally of quartz are common and conspicuous throughout the western part of the area. Original sandstones, arkoses, and quartz-pebble conglomerates have been changed into quartzitic rocks, which usually retain enough of their former structure to make their derivation a matter of certainty.

The finer grained or sandstone members are made up of small polyhedral grains of quartz, in most cases combined with minute yellowish scales of mica, muscovite, and a little biotite, but in some cases composed of quartz alone and then very friable or "sugary." The mica-bearing varieties usually have a decided schistosity dependent on the parallel arrangement of the mica flakes. In some localities the scales of mica serve to bind the quartz grains together, and, being flexible, allow a slight movement of the quartz grains, producing the flexible sandstone or itacolumite described at length by Lieber.[a] In these micaceous quartzites magnetite is commonly present and by its oxidation stains the rock pink, red, or brown. Under the microscope the polygonal outline of the quartz grains penetrated by foils of mica, usually muscovite, the numerous small octahedrons of magnetite, and the occasional crystals of garnet indicate that recrystallization has been considerable.

Some varieties, perhaps different in original composition or possibly subjected to different conditions of metamorphism, have fresh microcline instead of muscovite and hold numerous small, irregular grains of garnet.

The conglomerates are made up principa ly of quartz pebbles varying in diameter from a few millimeters to several centimeters, but most commonly 1 to 1½ cm. These pebbles have been almost everywhere much flattened and drawn out by pressure, and in many places the resulting mass can be determined as a conglomerate only by observing the gradual change into more typical facies. The matrix of the pebbles is in some places a green, slaty, sericitic, and chloritic material, rather abundant as compared with the bulk of the pebbles which it contains and wrapped around the pebbles in a manner recalling the flow lines of a porphyry. In other places the pebbles, large and small, compose nearly the whole of the mass and the cementing material is mainly silica, probably derived from partial solution of the pebbles.

Were it not for their flattening due to pressure, the pebbles would in most cases be well rounded. Surface specimens, however, frequently show a peculiar faceting of the exterior pebbles and sometimes suggest a rude approach to crystalline form; but large exposures show that this faceting is due to solution. The surface of the conglomerates is covered with pits and depressions exactly similar to those produced by solution in many limestones. The very decided solution which is thus evidenced probably has some relation to the conditions existing in a region near base-level already referred to (p. 13).[b]

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[a] Survey of South Carolina, vol. 3, 1859, pp. 75–106.

[b] Campbell, M. R., erosion at base-level: Bull. Geol. Soc. America, vol. 8, 1897, pp. 221–226. Cf. also Hayes, C. W., idem, pp. 213–220.

The quartz pebbles are now a granular aggregate of quartz grains, but whether they are portions of clastic rocks or have been derived from the breaking down of quartz veins, in which the rocks abound, and have been given their granular structure by crushing, it is impossible to decide, although the latter view is perhaps more plausible.

These quartz-rich metamorphic rocks are particularly abundant along the Kings Mountain Range, but also occur in places, isolated so far as known, farther east. They are more resistant than the surrounding rocks and hence outcrop conspicuously, forming the ridges of which Paysour, Crowders, Kings, Draytonville, Whitaker, and Thickety mountains are the highest portions, many smaller near-by ridges or mounds, and the elevations Henry Knob and Nannies Mountain. Notwithstanding this apparent resistance, these quartzitic rocks are in many places so rich in minerals like mica and magnetite, which are more susceptible to atmospheric decomposition than the quartz, that they crumble to soil with considerable readiness and do not form conspicuous outcrops. This variation in composition from place to place undoubtedly has had much to do with the unsymmetrical and irregular shape and distribution of the quartzite ridges. Conglomerate occurs along Kings Creek and makes up the greater part of Draytonville Mountain in Cherokee County. At the latter locality the surface of the rock is strewn with unevenly rounded pieces of quartz—the conglomerate pebbles which have been released by the decomposition or solution of their matrix. On the summit of this hill the conglomerate is exceedingly well exposed. This occurrence was noted by both Tuomey [a] and Lieber.[b]

QUARTZ-SERICITE SCHIST.

Closely related in composition to the quartzitic rocks described in the preceding section are certain schists which, when unaltered, are gray, glistening, micaceous, and much foliated. As generally seen, they are colored various shades of red by the oxidation of the magnetite which they contain. Some specimens hold an abundance of small red garnets. On disintegration they form a soil which gives little indication of the amount of mica which they held.

The microscope reveals in the thin section abundant quartz in rudely polygonal grains surrounded and enmeshed by shreds of fibrous muscovite or sericite. In places it appears as if numbers of these fibers had been so rearranged as to crystallize into an irregular flake of muscovite. Octahedrons and irregular grains of magnetite are rather common, and furnish, on decomposition, most of the coloring matter of the stained rocks. In a few cases turbid decomposed remnants of feldspar grains are being replaced by sericite. It seems probable that these rocks represent arkoses richer in feldspar than those from which the quartz schists were derived.

Quartz-sericite schists of this kind were not seen at many places in the area, probably owing in large part to the ready disintegration which they undergo. An occurrence of unknown extent was found in the northeastern part of Gaston County.

QUARTZ-BIOTITE SCHIST.

Dark-brown fine- and even-grained micaceous rocks are found at numerous places along the Kings Mountain belt. They consist of small grains of quartz, a little rather turbid feldspar, mostly oligoclase, and abundant brown biotite in small scales. Muscovite is present in some cases, and grains of carbonate are not unusual. Schistosity is well developed. They have probably been derived from impure feldspathic sandstones.

These rocks are found generally in close association with the limestone beds, though it is of course possible that they have a more extended development. They have been encountered in the limestone quarries at Gaffney and Blacksburg, S. C., and a similar rock is found at the Thompson mine, near West Springs, Union County, S. C.

SERICITE SCHIST.

Compact grayish or bluish-gray rocks, with a characteristic lustrous sheen on their parting planes, are known at various places along the Kings Mountain Range. They are made up almost wholly of sericite, and have probably resulted from the metamorphism of

[a] Rept. Geol. and Agr. Survey South Carolina, 1844, p. 18; Geology of South Carolina, 1848, p. 77.
[b] Survey of South Carolina, Vol. 2, 1858, pp. 40–42.

LIMESTONE QUARRY AT GAFFNEY.

Showing stratification and soil derived by decomposition of rock in place. Dolomitic beds above to right.

shales or other argillaceous rocks. They are associated with beds of manganese oxide and graphite and may represent deposits in comparatively shallow water.

A beautiful deep-green rock, which resembles a talc schist, forms the wall rock of the Blackmon mine in Lancaster County. In places the green color gives way to a silvery gray and pink, suggesting mother-of-pearl. This rock is almost completely made up of exceedingly fine fibers of sericite and contains, in addition, a few small dark-red garnets. It is probably a sediment much altered by regional metamorphism and by an intrusion of porphyry which has penetrated it.

LIMESTONE.

The limestones of this area can hardly be called schists, but they have been subjected to the same forces of metamorphism as the surrounding rocks and in many places, particularly near the limits of the beds, they are foliated and composed of other minerals in addition to calcite; in such places they possess a truly schistose appearance. These limestones are rather magnesian; the upper portion of the beds is in places too high in magnesia to make lime, and is practically a dolomite. The dolomitic portions are usually light gray to white in color and the more calcareous varieties are generally blue. The quarrymen are pleased to find "blue rock," while the white they speak of as "dead." Below are given the analyses of some typical limestones of this area, which the writer owes to the courtesy of Dr. Earle Sloan, State geologist of South Carolina:

Analyses of typical limestones.

	1.	2.	3.
SiO_2	0.71	1.28	1.16
Al_2O_3	.23	.23	.....
Fe_2O_3	.47	.47	.96
MgO	1.16	5.60	25.48
CaO	54.24	48.66	30.50
Na_2O	.02	.08	.....
K_2O	.01	.01	.....
H_2O at 100	.02	.06	.03
TiO_2	Trace.	Trace.	.....
P_2O_5	Trace.	Trace.	.....
CO_2	43.27	43.52	.....
Loss on ignition	.11	.12	.....
	100.24	100.03	.....

All these specimens are from near Gaffney. No. 1 represents very pure limestone; No. 2 indicates a rock that is somewhat less pure, but makes very good lime; No. 3 is a partial analysis of a magnesian or dolomitic phase, which is not burned for lime.

Mineralogically, these rocks consist principally of granular carbonate, whether calcite or dolomite can not be told by means of the microscope. Small lenses and bunches of quartz, probably introduced at the time of the metamorphism of the region, occur in some specimens. A little colorless amphibole, probably actinolite, and thin blades of a colorless or whitish mineral, presumably wollastonite, are rather commonly observed. At the edges of the limestone masses the rock passes over within a short distance, yet by gradations, into the adjoining rock—feldspathic quartzite in some places, quartz-biotite schist in others.

The limestones are known to occur at numerous points through practically the whole extent of the Kings Mountain Range. A good view of the limestone in one of the quarries at Gaffney is shown in Pl. II.

IGNEOUS ROCKS.

The rocks described under this section are those which were intruded and reached their present position after most or all of the metamorphism which affected the rocks described in the foregoing pages had taken place. They exist at the present day, therefore, in practically the same state in which they crystallized from their molten magmas. These rocks have a small areal extent as compared with the metamorphic rocks. They appear either as dikes or as elongated bodies, whose shape was influenced by the structure of the rocks which they penetrated.

GRANITE.

Granite is the most abundant of the massive igneous rocks. It is of light color, medium grain, and typical granitic texture. Exposures of large size sometimes show the rock to be almost structureless—that is, devoid of any foliation—but in most places a more or less distinct gneissic structure is observable, in spite of the fact that hand specimens may appear nearly or quite massive. This granite is rich in the lighter-colored constituents, which include muscovite, and contains a rather sparing amount of brown biotite.

The microscope shows the presence of abundant quartz in clear grains, holding numberless fluid inclusions of the ordinary kind. Microcline is the predominant feldspar, followed in decreasing amounts by orthoclase, oligoclase, and albite, all fresh. Muscovite is plentiful in broad, thin foils. Deep red-brown biotite is not very abundant. By its bleaching, some of the muscovite may have been formed. Some of it has been changed to chlorite. Scattered garnets, a few crystalline grains which are probably epidote, one or two small zircon crystals, and numerous prisms of apatite complete the list of constituents.

A comparison of this description with that of the granitic gneiss (pp. 16–17) in the section on metamorphic rocks shows that the two types of rock are practically identical mineralogically. While the field relations are not very distinct and have not been carefully studied, it is believed that they likewise favor the view that the foliated granite or gneiss and the massive granite were derived from a common magma and belong to the same general period of intrusion. If this is true then the eruption of the granite must have marked the closing stage of the regional metamorphism of the country; otherwise, all the granite would be foliated. The difference in amount of foliation of the granite and the gneiss may partly be explained by the reasonable supposition that these last metamorphic movements were not equally intense in all portions of the area. It seems probable, however, that other conditions were largely responsible for this difference in foliation.

It has just been stated that the granite and the gneiss probably belong to the same general period of intrusion. This does not mean, however, that all the masses of these rocks were intruded at the same absolute time. It is doubtful, indeed, if instances of such kind are at all common. On the other hand it is reasonable to suppose that successive intrusions took place and that the interval from the beginning to the end of eruptive activity was considerable. Since this epoch of eruption probably began just as the great movements of compression and folding were dying out, the first of the granitic intrusions would suffer more or less squeezing and shearing and would be converted into a granitic gneiss, while successively later portions of the granite magma to be forced up into the metamorphosed rocks would be subjected to less and less dynamic action, and the last of the granite would appear after metamorphic movements had ceased, and would thus remain massive.

PEGMATITE.

The dikes of pegmatite which abound in the western part of the area studied form one of the most interesting geologic features of the region. Several varieties of pegmatite may be distinguished, although it may be that all are members of a series in which certain varieties are most common or abundant. Of the types established several exhibit a considerable variation in mineralogical composition, so that it is not at all improbable that a further slight change would result in a passage to the neighboring type. Although these rocks are of various appearances, they all possess features which at once characterize them

as pegmatites. In composition they are all closely related to granite. In the following paragraphs the four most common varieties are described in the probable order of their formation.

The first variety is usually of light color and not very coarse grain. It occurs in small contorted lenses and dikes in the granite and surrounding rocks. Microcline, quartz, oligoclase, orthoclase, and muscovite are present in decreasing amount. Small red garnets are numerous in some specimens and ilmenite is a prominent constituent of some of the small masses. Crushing can be seen to have taken place in much of the rock. In some cases it appears as if contortion had gone on while the pegmatite was unsolidified.

The pegmatite of the second variety is a light-colored rock, much of it somewhat foliated or gneissic, whose chief constituent is feldspar. The microscope shows large individuals of orthoclase with well-developed cleavage, some of them with microperthitic intergrowths of albite. Numerous smaller grains of albite also occur near the periphery of the orthoclase individuals. Narrow tongues of quartz appear to be eating into the feldspars and are surrounded by small grains of micropegmatite—a granophyric intergrowth of quartz and feldspar. Small shreds and scales of brown biotite are plentiful in some parts of the section, and associated with the biotite particularly are small prisms of monazite. In thin section this mineral is pale yellow, and has a high index of refraction and apparently rather low double refraction. In many places the dikes contain flakes of graphite, whose origin is undoubtedly primary.

Dikes of this kind are rather common in the western part of Cherokee County, where they are injected into gneiss and amphibolite, and where, on sufficient decomposition, they are sometimes worked for monazite.

The third variety of pegmatite is very light colored and fairly coarse grained. In most places quartz and feldspar are the only constituents visible in the hand specimen, but in some places muscovite is present and locally cassiterite becomes an essential constituent. It is rather easily decomposed and weathers to a soft mass chiefly made up of kaolin.

Microcline is abundant in large individuals penetrated by grains of albite and by long, narrow tongues of quartz, which look as if they had eaten their way into the feldspar. Along the borders of these larger quartz individuals are small grains of different orientation. The quartz is crowded with fluid inclusions. Much of the muscovite is converted into the fibrous variety, sericite, by crushing. Cassiterite, when present, occurs as crystalline grains of dark color and pleochroic under the microscope. This kind of pegmatite is known only in the vicinity of the Ross tin mine, near Gaffney, Cherokee County, S. C. In some respects it resembles the monazite-bearing pegmatites from the western part of Cherokee County, and the occurrence of a notable amount of monazite in the bed of the stream which crosses the dikes of the Ross property may be an indication that this variety also is monazite bearing. Neither biotite, monazite, nor graphite has been found in the Ross dikes, however.

A slight change in composition of the pegmatite of this class would probably result in the production of the fourth variety.

The fourth kind of pegmatite consists very largely of quartz and muscovite. It is coarse grained, some of the mica flakes attaining a width of 10 cm., and in this way merits the name "giant granite" sometimes given to it.

As a rule feldspar is absent or only sparingly present, but in certain cases good-sized crystals of feldspar are rather abundant. Where these dikes penetrate the metamorphic rocks they seem in general to contain much mica and little or no feldspar. Where they cut the granite or granitic gneiss, on the other hand, they usually hold a plentiful amount of feldspar and decidedly less muscovite. Cassiterite is in some places an important constituent and seems to be most abundant in the mica-rich varieties. Among other minerals which have been found in these dikes are large but imperfectly terminated crystals of spodumene, violet-blue or bright-green apatite, and a brownish or yellowish-brown lithia-manganese phosphate, probably lithiophilite. These dikes are in some places so resistant to atmospheric agencies as to outcrop conspicuously. Many of them are very friable, however, and hence disintegrate and are concealed by soil. This variety of pegmatite is

described at greater length in the section devoted to the occurrence of tin (pp. 31–32). Dikes of this rock appear or have been exposed in many places along the Kings Mountain Range. They extend in a belt which crosses Lincoln, Gaston, Cleveland, and Cherokee counties, and passes beyond the limits of the area concerned in this report.

The possibility that the various types just described may be members of a continuous series has already been stated. Whether such is the case or not, it seems probable from the amount of foliation which each has suffered that the types appeared in the order described. The first variety is almost always considerably crushed. The others are progressively less affected and the fourth variety only here and there gives evidence of having been deformed.

In the description of the granite (p. 20) the opinion is expressed that the gneiss and granite belong to the same period of intrusion, were derived from the same magma, and differ only in having suffered unequal amounts of squeezing consequent on being erupted at somewhat different times. It is here proposed to extend this hypothesis still further to aid in explaining the origin of the pegmatite.

Pegmatite of the first variety cuts the granite and suggests at once the conclusion that it was a part of the granite magma. The other varieties of pegmatite were nowhere found cutting massive granite. In the northwestern part of Gaston County, however, pegmatite dikes of the fourth type are abundant in the somewhat gneissic granite, and the impression conveyed by the appearance of these dikes is that they are related to the rock which they cut. If the granite were not foliated, it might be said without hesitation that the pegmatite dikes represent the last phase of the eruption which resulted mainly in the production of granite. The fact that the granite is rather gneissic, however, while the pegmatite is practically uncrushed, indicates that considerable time has elapsed between the intrusion of the two rocks. This would, in general, be sufficient to prove that the two could not have been derived from the same magma. In this case, however, it is believed that a particular combination of circumstances accounts for the seeming paradox of pegmatite cutting its parent granite after the latter had been rendered gneissic.

If the gneiss is really the earliest portion of the granite magma, which happened to be caught in the grasp of expiring dynamic metamorphism, and if the last of the granite was late enough to escape nearly all the squeezing—in other words, if the granite and gneiss are related—it is conceivable that pegmatite and gneiss can bear exactly the same relation to each other as pegmatite and granite.

It is believed, in short, that the pegmatite—the residuum from the solidification of the granite, the last of the material to be ejected in a molten state from the magma reservoir—appeared after almost all regional metamorphism had subsided, and, coming from the heated interior, where the effects of surface folding were not felt, cut the gneissic and the massive granite indiscriminately, except that the gneiss, having been subjected to pressure and stress, was probably weaker and allowed an easier access of the material than the massive granite. Such a hypothesis, if true, would account for the relation of the pegmatite to the foliated granite and for its greater abundance in that phase of the rock. It is realized that this theory is open to the criticism that it is based on an artificial and perhaps unwarranted grouping of favorable conditions. But the intimate lithologic connection between gneiss and granite and the close relation of pegmatite and gneiss, added to the fact that the pegmatite is almost certainly related to some mass of granite, have favored the acceptance of this hypothesis.

PORPHYRY.

In a few places masses of rock with porphyritic texture intrude the surrounding schists. These masses are in all known occurrences closely associated with gold deposits and are in consequence much altered. In general they are light-grayish, granitic-looking rocks, of moderate grain. Phenocrystic grains of quartz are visible in many hand specimens. In the least altered rock from the Brewer mine crystalline individuals of an unknown mineral (see p. 90) are easily recognizable.

Under the microscope the rocks are seen to consist of good-sized individuals of quartz, some of which are developed as bipyramids, and very turbid crystals of orthoclase and oligoclase, decomposing into kaolin, sericite, and epidote. In the rock from the Brewer mine large individuals of the unknown mineral are being slowly converted into sericite. The matrix for all these individuals is a fibrous mass of sericite. Magnetite is present in some specimens and is probably secondary. Pyrite is abundant in places. A little rutile has probably been formed by the decomposition of some original titanium-bearing mineral. There is no indication that dark silicates were ever present.

These porphyries have been found at the Brewer mine in Chesterfield County and at the Blackmon mine in Lancaster County. It is probable that they are closely related to the tuffs found at the Haile, Colossus, and Ferguson mines. While it is difficult to determine the original character of these rocks, because of their altered condition, they probably belong in the quartz-monzonite-porphyry group. At the Brewer mine the porphyry shows in places the effects of brecciation.

Keith[a] has described a series of volcanic rocks from the Cranberry quadrangle, about 80 miles northwest of the area embraced by this report. The rocks there are considered to be altered rhyolites, andesites, basalts, and diabases, and are thought to be of Algonkian age. Keith believes that the porphyritic rocks in the two localities are similar.

DIABASE.

Dikes of diabase occur at many places through the area studied and represent the last phase of eruptive activity experienced here. These bodies range from a few to 200 or more feet in width, and cut any or all of the other hard rocks of the district. The material of the dikes ranges from moderately to very fine grained and is of greenish-black color. Individual minerals can with difficulty be determined by the unaided eye. The rock is fairly resistant to weathering and, although seldom outcropping, furnishes much float which marks the course of the dikes. It weathers in the concentric layers characteristic of diabase.

In thin section the rock is found to be a typical olivine diabase. Plagioclase, a calcic labradorite, in long, narrow laths, was the first mineral to form. Olivine is generally abundant and occurs mainly in automorphic crystals, but here and there in irregular grains. On decomposition it changes into the mineral called iddingsite, which, in these rocks particularly, seems certainly to be a micaceous mineral. Less commonly it alters to a material which is of almost identical appearance in ordinary light, but which is isotropic. In a few places serpentine results from the olivine. Augite is abundant, usually as irregular interstitial individuals, but locally in crystals of fairly good form. It is slightly pleochroic in colors suggesting a small content of titania. Cleavage is very well developed. Some of the pyroxene may be diallage. Closely associated with the olivine and commonly included in it are numerous small octahedral crystals of perofskite. The exterior of the crystals is nearly opaque, while the interior is a rather dark brown. Small crystalline grains of black iron ore, probably titanic, are especially associated with the pyroxene. The ophitic texture is beautifully exhibited.

SEDIMENTARY ROCKS.

Sediments which have been deposited since the cessation of regional metamorphism and which are, in consequence, present in the state in which they were laid down, are of unimportant extent in this locality.

"MONROE" BEDS.

Extending for a considerable distance about Monroe, Union County, N. C., are horizontal or slightly tilted beds of fine-grained material, well stratified. They were seen by the writer only to the southwest of Monroe, and the following description applies only to that part of their area. They are considerably affected by decomposition, and colored yellowish or

[a] Geologic Atlas U. S., folio 90, U. S. Geol. Survey, 1903.

pinkish by the oxidation of the iron which they contain. Along the joint planes thin films of limonite have been deposited.

The appearance of the rock at once suggests that it is a tuff. No conclusive evidence has been found to prove this assumption. Porphyritic crystals have not been observed and the microscope shows only very minute grains of quartz and of some other mineral much obscured by limonite stain. The fact that fossils have never been found in these rocks is a negative evidence in favor of their being volcanic tuffs.

SAND.

In places along the eastern part of the territory traversed are areas covered with a clean, loose quartz sand. This is the country of the "long-leaf" or turpentine pine. This deposit is in most places known to be thin, resting on the Piedmont rocks, and is doubtless a part of the Coastal Plain formations. It is regarded by Doctor Sloan as probably of Quaternary age.

CLAY.

Comparatively small bodies of clay, like that near Grover, N C., occur in isolated localities. They probably represent deposits, in small basins, of material derived from the decay of the other rocks.

ALLUVIUM.

Along some of the streams small flood plains have been formed. They are built up of the detrital material which the streams have been forced to deposit and consist principally of sand and gravel. These plains are, of course, the most favorable localities in which to search for placer deposits of valuable heavy minerals, such as gold, monazite, cassiterite, etc.

EFFECTS OF METAMORPHISM.

REGIONAL METAMORPHISM.

As may be gathered from a statement of the relative extent of the three great classes of rocks, this is a region characterized by the presence of metamorphic rocks. The principal effects of the agencies which caused the changes from their original to their present form have been described in the section dealing with the metamorphic rocks (pp. 14–19).

In structure the changes have been from the stratified sediments, bedded tuffs, and massive igneous rocks to the wholly crystalline and generally much foliated schists. It appears probable that these mechanical changes have not been accompanied by marked changes in chemical composition; but in some cases, as that of the quartzites, there has been pronounced silicification, while in the amphibolites some lime has doubtless been removed. The molecular or mineralogical changes, however, have been great. Feldspars have been changed to sericite or to epidote, zoisite, calcite, and a less calcic feldspar. Pyroxene has been changed to amphibole. Impure kaolin has become sericite and biotite. Garnet is a common product in many of the rocks.

CONTACT METAMORPHISM.

The changes induced in the surrounding rocks by the intrusion of igneous masses are of much less extent in this portion of the Carolinas than those produced by dynamic forces. Nevertheless the heat, pressure, solutions, and vapors caused by or accompanying the molten material have in this region had a very noticeable effect along the contacts of the igneous bodies. In most cases the structure of the original rock has not been altered, but has instead impressed itself on the new minerals developed, so that the change is a pseudomorphous replacement. In only a few instances has a new foliation been developed parallel to the contact of the intruding mass.

Unlike the effects of regional metamorphism, the results at the contact of igneous bodies have been accomplished by more or less intense chemical and consequent mineralogical

changes. The nature of the intruding rock, however, has had much to do with the degree of metamorphism. The diabase dikes effect in the wall rocks very little change beyond a rather slight induration. Granite, on the other hand, has produced very pronounced changes. Little opportunity was found to examine the effects of the large granite masses, but in the case of some of the smaller dikes the results can be well studied.

In amphibolite the secondary, uralitic hornblende is generally converted into a biotite which under the microscope possesses the clear, chestnut-brown color characteristic of mica of this origin. In a few cases a lavender amphibole, related to glaucophane, accompanies this secondary biotite. It appears in long, slender prisms of amphibole outline, with cleavage not so perfect as is common in hornblende. A transverse parting is also present. The plane of the optic axes is the clinopinacoid and the maximum value of the angle $\mathfrak{c}:\dot{c}$ is 16°. It seems probable that this orientation of the axes of elasticity is somewhat variable, for most sections give a much smaller extinction angle. The character of the double refraction is positive. Pleochroism is noticeable, as follows: $\mathfrak{a}$=pale yellow to colorless, $\mathfrak{b}$=very delicate lilac, $\mathfrak{c}$=lavender; $\mathfrak{c}>\mathfrak{b}>\mathfrak{a}$. Some of the amphibolite is tinged with a border of a green, strongly pleochroic mineral, of fairly strong double refraction, which may be another amphibole intergrown with the lavender variety. Small red garnets are developed in some abundance, tourmaline and magnetite are introduced in certain cases, and not uncommonly small grains of sulphides, pyrite, pyrrhotite, and chalcopyrite, many of them intergrown, impregnate the wall rock. These changes become less prominent away from the contact, but the secondary biotite has been found more than 10 feet from the granite.

The effect on rocks other than amphibolite has not been carefully studied. The principal result seems to be the development of the brown biotite.

Pegmatite as a rule acts in a similar way to granite, except that its action is in most cases much less pronounced. In a few instances, however, tourmalinization of the immediately adjoining wall rock has been exceedingly intense. Garnets and sulphides are seldom seen at the contact of pegmatite dikes.

The metasomatic replacement effected by quartz-vein solutions in their wall rocks is in these southern deposits strikingly like that produced by contact metamorphism. This feature is dwelt on at greater length under the heading "Gold" (pp. 63–64), but it may be said at this point that tourmaline, garnet, magnetite, and sulphides characterize the wall rocks of many of the quartz veins and the resulting products are in some cases almost indistinguishable from those caused by granite or aplite dikes. Porous rocks, like the acidic volcanic tuffs, have in many places been subjected to intense silicification.

All these results of contact metamorphism bear evidence that they were produced at great depths and have been exposed only by profound erosion.

HYDROMETAMORPHISM.

Throughout the southern Piedmont region the effects of weathering are very prominent. In many places marked decomposition of the rocks has extended over 100 feet below the surface. It is believed that the physiographic history of the region has allowed this weathering to proceed to so great a depth. With the slow rate of erosion as base-level was attained and the help of those conditions which are supposed to exist at such a stage, decomposition of the rocks exceeded erosion of the products of decomposition and in consequence extended to very unusual depths. This decomposition seems to have been, except perhaps within a few feet of the surface, much more a hydration than an oxidation—a fact which probably indicates that there was sluggish circulation of the waters that caused this change. So far as they have been studied, the principal products of this hydration are kaolin and chlorite. Magnetite is oxidized to limonite near the surface and colors red or brown all the rocks which contain it. The amphibolites thus produce a very red soil, while much of the magnetite-bearing itacolumite is stained red or pink. The quartzites become friable, partly from solution of the cementing silica and partly from decomposition of the mica which helps bind the grains together. The limestones are dissolved,

leaving a small amount of red residual soil at the surface. (See Pl. II.) The granites and gneisses are much less affected than the more schistose rocks, but are somewhat decomposed near the surface, the principal change being the conversion of feldspar into kaolin. Those pegmatites which are poor in feldspar are fairly resistant to decomposition, and some of them outcrop distinctly; but the feldspar-rich varieties are readily affected by weathering. In most cases where observed, the porphyritic and tuffaceous rocks have been sufficiently silicified to enable them to resist extreme decomposition. The diabase dikes very commonly outcrop in the characteristic "nigger-head" fashion, showing that the rock has not been greatly decomposed.

STRATIGRAPHY AND STRUCTURE.

The broadest features of the structure of this area and its relation to the rest of the Appalachian province have been outlined on pages 10–11. All the foliated or schistose rocks strike in a northeasterly direction, varying from N. 20° E. to N. 65° E., and dip at high angles, usually between 45° and 90°, either to the northwest or to the southeast, but probably most commonly to the northwest.

Undoubtedly the best place for studying the structure within the area described is along the Kings Mountain Range, particularly in the vicinity of Blacksburg, S. C. The stratigraphic relations are much more evident there than elsewhere and furnish the necessary key for deciphering the structure. Moreover, the intimate dependence of the distribution of the tin deposits on the structure of the Kings Mountain belt warranted the expenditure of more time on the examination of the geology of this particular locality than was possible in other places. Yet even here the study was so hasty that the writer does not feel justified in attempting to enumerate, in exact order, the formations which occur, nor to represent their respective attitudes in a sketch. The Kings Mountain belt will be first described and remaining portions of the area will be considered later.

KINGS MOUNTAIN BELT.

RELATIONS OF THE ROCKS.

The Kings Mountain Range is made up of nearly all the schistose rocks described in the preceding pages. A broad view in the field confirms the idea that many of these rocks are of sedimentary origin by revealing a stratigraphic succession characteristic of sedimentary formations. Impure quartzites, biotite and sericite schists, and partially marmorized limestones, representing original sandstones, conglomerates, shales, and limestones, are bedded with true sedimentary regularity. At the limestone quarry south of Gaffney, S. C., the limestone is seen passing upward into impure quartzite, which is exposed in typical development along a road not far to the northeast. On the west bank of Kings Creek, near the point where it enters Broad River, a quartz-rich conglomerate with a chloritic matrix is exposed. It probably represents a transition into the quartzitic beds which occur just above, capping the bluff on the eastern side of the creek. On the summit of Draytonville Mountain is a similar occurrence of much-metamorphosed conglomerate passing into quartzite.[a]

Intercalated with these several rocks are layers of iron and manganese ores and bands of graphite or graphitic schist. As might be expected, these beds are less persistent and regular than the strata which inclose them. It is believed that the iron, manganese, and graphite beds represent localized deposits in bogs or swamps, while the sandstones, shales, and limestones were deposited in much more extensive basins, possibly in the ocean itself. It should be stated here, however, that not all the iron deposits of the Kings Mountain belt are attributable to such an origin.

[a] Cf. Tuomey, M., Rept. Geol. and Agr. Survey South Carolina, 1844, p. 18; Geology of South Carolina, 1848, p. 77; and Lieber, O. M., Survey of South Carolina, vol. 2, 1858, pp. 40–42.

From evidence furnished by the structure which is described in the next section, a succession has been determined which is probably fairly correct. Beginning with the lowest member the rocks are biotite schist, limestone, biotite schist, sericite schist, conglomerate, quartzite, graphite, or graphic schist, sericite schist containing a bed of manganese ore, beds of iron ore, sericite schist. The thickness of the beds was not determined.

These strata are penetrated or separated by layers of amphibolite lying in parallel position. It seems probable that part of the amphibolite represents intercalated intrusions into the sediments, while part represents interstratified deposits of basaltic tuff or flows of basalt lava. Ancient bodies of granite, now converted into a more or less foliated gneiss, are likewise intercalated with the other rocks. More recent intrusions of granite, pegmatite, and diabase have also penetrated these strata.

STRUCTURE.

The strike and dip which are most prominent in these rocks are dependent on the direction of schistosity or foliation induced by movement. But it is found that the foliation is parallel to the bedding of the rocks. There may be in some cases a slight divergence of the plane of schistosity from that of sedimentation, but such was not observed. A determination of the strike and dip of the foliation will therefore throw light on the structure and position of the sedimentary strata and hence will indicate what changes have taken place since the beds were deposited in their originally horizontal position.

A traverse across the Kings Mountain Range in the vicinity of Blacksburg shows that the ridges are composed of the hard, resistant quartzites and that the valleys between mark the position of the softer schists and the limestone. Starting near the North Carolina boundary and passing along a southeasterly line through the town of Blacksburg, the observer encounters the upturned edges of the beds enumerated above, beginning at the top. These rocks dip steeply to the northwest; in places they are nearly vertical. To the southeast from Blacksburg the same rocks are observed but in the reverse order and generally dipping very steeply to the southeast, although in some cases—for instance, the quartzite of Kings Mountain—the dip is steep to the northwest.

It is evident that the rocks are, in general, symmetrically arranged with respect to an axis which lies between the two layers of limestone.[a] While the evidence is not so conclusive as would be desirable, it seems probable that the dips on the opposite sides of this axis are, in general, away from each other. In other words, this strip of country is probably an anticlinal fold, with its axis running northeast and southwest. Blacksburg is situated just northwest of this axis. Because of their comparatively small extent, the beds of iron and manganese ore and the conglomerate do not always form continuous outcrops and are not always present on both sides of the fold. With these exceptions the repeated succession in reversed order is very distinct. Local variations in the dip between the exposures of limestone and quartzite on the southeast limb of the fold indicate that minor folding has taken place and has formed a part of the main anticline. Another deviation from exact symmetry on the two sides of the axis is the fact that the dips on the southeast are rather steeper than those on the northwest limb of the fold, with an actual reversal to northwesterly dip in some places on the southeast side. This indicates an approach toward isoclinal structure with dip to the northwest.

If the results of this folding had not been modified by erosion, a steep-sided ridge much higher than Kings Mountain or Whitaker Mountain would be present to-day. But after the folding had taken place, erosion wore away the highest parts, so that the crest of this fold has now been completely cut down. The rate of erosion has been slowest on the resistant quartzite, which therefore remains higher than the surrounding rocks. Viewed in this way it is probable that the two beds of limestone were once parts of a single, continuous, flat stratum and that the quartzite of Whitaker Mountain and of the ridge extend-

[a] Cf. Tuomey, M., Geology of South Carolina, 1848, p. 76. Only one of these limestone outcrops was seen by the writer. Old pits are said to have been made on the other limb and now to be caved in and filled.

ing southwest from Kings Mountain were similarly connected when in their original horizontal position. The schist which appears between the two limestone beds is the lowest member of the series exposed, and the schist overlying the quartzite is the highest member which can with certainty be assigned a definite geologic position.

In some places along this belt only one bed of limestone has been found; in other places three or four layers are said to occur. It may be that two strata of limestone are present; if so, four outcrops would normally occur wherever erosion has extended sufficiently deep to cut the lower stratum. If the lower stratum is barely exposed, then three bands would appear on the surface, while if erosion had cut down only to the upper bed but one band would be exposed on the surface. On the other hand, it may be that faulting parallel with the axis of the fold has caused a repetition of some of the beds by uplift or a disappearance of some by depression. However, since the limestone outcrops are generally obscured by coverings of clay and other detrital material, it is easily conceivable that outcrops actually present have never been discovered. Since limestone is the one member of the series by which the details of structure are at all readily deciphered, and since the data which it furnishes are not conclusive, it is impossible without further study to decide the direction and amount of pitch of the fold and whether or not faulting has taken place.[a] Both Tuomey[b] and Lieber[c] recognized this anticlinal structure.

The foliation of the igneous masses, the amphibolite, and the gneiss is of course parallel with that of the sedimentary rocks, since both were subject to the same forces.

Granite, pegmatite, and diabase have been intruded since the folding and foliation took place, and hence are massive and almost unchanged. The form and distribution of the granite and pegmatite bodies were largely influenced by the structure of the rocks which they invaded, and hence they are elongated masses striking with the surrounding rocks. The pegmatite of course occurs as dikes. The diabase also is in the form of dikes, but more commonly cuts across the formations than runs parallel with them.

The general trend of the Blacksburg anticline is northeasterly, but certain irregularities are worthy of mention. At Gaffney, S. C., the rocks and the axis of the fold strike about N. 45° E. From a short distance northeast of Gaffney to Kings Mountain the strike is about N. 55° E. Thence into Lincoln County the strike is about N. 20–25° E. This jog or bend in the fold near the State line corresponds on a reduced scale with the similar change of trend of the Appalachians to the northwest.

An interesting side light on the structure of this region is the behavior of the well which supplies the water for the town of Gaffney, S. C. This well, about 550 feet deep, is said to be wholly in schistose and gneissic rocks. With the exception of such minor elevations as Draytonville and Thickety mountains and slight ridges and valleys occurring here and there, the country is practically level for miles around. In spite of this fact, the well for some time after completion was of the artesian type, a steady flow of water rising several inches above the top of the pipe. This phenomenon may possibly indicate that Gaffney is located on a syncline, but is probably to be explained by some other peculiarity of structure.

OTHER PARTS OF THE AREA.

Interpretation of the structure in other portions of the area is much more difficult, principally because of the lack of distinctiveness in the formations exposed. Quartzite is known in isolated localities, as on Henry Knob and Nannies Mountain, but definite stratigraphic relations have not been found outside of the Kings Mountain Range, where the limestone is the main factor in solving the problem.

Nevertheless, it is believed that the general conclusions reached in the Kings Mountain belt may be applied to some extent to other portions of the region. It is probable that a fold so marked as the Blacksburg anticline would be accompanied by—would, in fact, be

[a] Lieber, O. M., Survey of South Carolina, vol. 3, 1859, pp. 112, 116.
[b] Rept. Geol. and Agr. Survey, South Carolina, 1844, p. 16; Geology of South Carolina, 1848, p. 99.
[c] Op. cit., vol. 1, p. 92, Pl. V. Cf. also Nitze, H. B. C., Bull. North Carolina Geol. Survey No. 1, 1893, map opp. p. 85.

only one of—many other similar folds. In regions of intense movement isoclinal or overturned folding is very common. It seems probable that almost or quite the whole of the area has been subjected to repeated folding, with axes trending in a northeasterly direction. Prevailing isoclinal folds would account for the predominant northwesterly dips, while southeasterly dips could be explained by the presence of more nearly symmetrical folds, like the Blacksburg anticline. Thrust faulting may also have taken place. Such an explanation accords with the accepted idea of structure elsewhere in the Appalachian province, where conclusions can be more safely drawn. Careful and detailed study will be required to prove the truth or falsity of this hypothesis.

At one place the structure is worthy of mention. The "Monroe" beds, southwest of Monroe, N. C., are very well bedded and in most places have only small dips. In several places cuts along a new road expose a structure illustrated in fig. 2. The beds are bent up as if by a thrust from below and are broken and crushed. The material in the crushed zone is of the same character as that of the beds. This structure resembles the products of some of Willis's [a] experiments in the folding of sediments. It is a fold-fault produced by compression, and probably results from expansion of the beds due to atmospheric alteration.

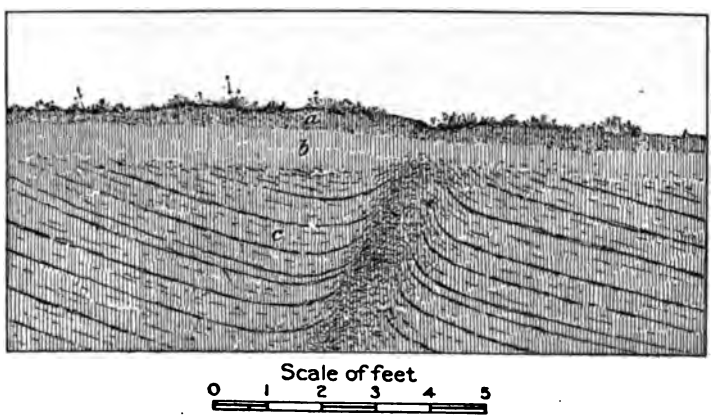

FIG. 2.—Sketch of exposure along road west of Monroe, N. C., showing disturbance of "Monroe" beds. *a*, Soil; *b*, disintegrated tuff; *c*, volcanic tuff.

AGE OF THE ROCKS.

Almost from the beginning of geologic study in this region the age of the rocks has been the subject of much investigation and speculation. The earlier workers found slight encouragement in the results of their labors, and it must be admitted that our views have advanced very little beyond theirs. It used to be supposed that practically all the ore deposits of these Southern States were contemporaneous in origin with the inclosing rocks. Attention was therefore directed principally to the metamorphic rocks, in which most of the deposits of economic value occur.

METAMORPHIC ROCKS.

From their crystalline structure and the absence of organic remains these schistose rocks were first supposed to represent part of the original crust of the earth and were called primitive or primary. Emmons [b] in his report of 1856 considered these rocks as the oldest sediments of the globe and placed them at the base of the Paleozoic, in what he called the Taconic system. On the basis of what he supposed to be fossils, he concluded that

[a] Willis, Bailey, The mechanics of Appalachian structure: Thirteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1893, Pls. LXXV, a'; LXXXII, e.
[b] Emmons, E., Geol. Rept. Midland Counties of North Carolina, 1856, pp. 41–45, 60–64.

these rocks contain the first record of life on the earth. It was later shown that the specimens which he supposed to be fossils were not of organic origin. Lieber, working in the late fifties, regarded the Kings Mountain series as Silurian.[a] Kerr [b] in 1875 placed the Kings Mountain series in the Huronian system and considered the other rocks of the area as Laurentian. Becker [c] and Nitze[d] concluded that the metamorphic rocks of the central Carolinas were of Algonkian age.

From the description of these rocks and their structure Dr. C. W. Hayes favors the view that they are Cambrian, and hence that the Blacksburg fold is a syncline—one of a series to which belong several others known in the region farther west.

Acquaintance with the rocks occurring to the northwest of this area leads Mr. Arthur Keith to believe that the schistose rocks here described belong somewhere between the beginning of the Cambrian and the end of the Carboniferous; that the metamorphism which affected them took place in or at the close of the Carboniferous, and consequently that the unfoliated igneous rocks are post-Carboniferous.

Satisfactory proof of the presence of fossils in these rocks has never been made, although the discovery of organic remains has been several times reported.[e]

It seems unlikely that the age of these rocks will ever be determined by biologic evidence, because it is doubtful if such evidence, even if it has ever been present, is preserved. It is conceivable, however, that some place in the limestone may be found where there has been so little alteration that fossils may remain and be identified.

It is far more probable that the age of the rocks will be determined only by stratigraphic methods. Extremely careful study, consisting in tracing formations and gradations in character from rocks of known age continuously up to these very rocks, will be required to reach final conclusion by lithologic or structural correlation. Any opinion based on no more definite stratigraphic relation to known rocks than has yet been found can at best be only tentative.

These metamorphic rocks are in some places on the east overlain by beds of the "Newark" system, now regarded as Triassic, showing that these rocks must have been formed and rendered schistose before Triassic time. The last intense metamorphism which affected the rocks of the eastern United States took place in the Carboniferous period. These rocks must therefore be Carboniferous or older.

Several facts point to pre-Cambrian as the probable age of these rocks. The seemingly entire absence of fossils is such an indication. So far as known to the writer, proved Paleozoic rocks in the Southern Appalachians are by no means so much metamorphosed as the schists here described. As stated by Mr. Lindgren, also (p. 120), granite is nowhere known in the South intrusive into rocks proved to be Cambrian or younger. Yet the metamorphic rocks here described are cut by granite which in many places is little or not at all foliated. In the Cranberry quadrangle, about 80 miles to the northwest, folded sediments, somewhat metamorphosed in places, and, assigned by Keith to the Cambrian, unconformably overlie gneisses, schist, and intrusive granite which appear to correspond in a general way to the rocks of the area here concerned. Keith shows that the underlying rocks were much metamorphosed previous to the deposition of the Cambrian.[f] It seems probable that the rocks of this central Carolina region belong to the same pre-Cambrian complex as those in the Cranberry district. In support of this view, the porphyritic rocks here described certainly cut some of the schists, and corresponding tuffs are interbedded with the schists. As has been stated on page 23, Keith considers the porphyries of this region similar to the volcanic

[a] Lieber, O. M., Survey of South Carolina, vol. 3, p. 149.
[b] Kerr, W. C., Geology of North Carolina, 1875, p. 133.
[c] Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 260.
[d] Nitze, H. B. C., Bull. North Carolina Geol. Survey No. 3, 1896, p. 44.
[e] Cf. Lieber, op. cit., vol. 2, pp. 87–88; vol. 3, p. 149; Emmons, E., Geol. Rept. Midland Counties of North Carolina, 1856, pp. 60–64; Marsh, O. C., Am. Jour. Sci., 2d ser., vol. 45, 1868, p. 217.
[f] Geologic Atlas U. S., folio 90, U. S. Geol. Survey, 1903.

rocks in the Cranberry quadrangle which he considers pre-Cambrian. These porphyritic rocks have likewise been regarded as pre-Cambrian by others.[a]

From all the facts available it seems most reasonable to regard these rocks, and the metamorphism which affected them, as probably of pre-Cambrian age. While a more conclusive statement can not now be made, the writer believes that later detailed study will confirm this view.

IGNEOUS ROCKS.

The igneous rocks which are now represented by granitic gneiss and amphibolite first cut the sediments and then were metamorphosed with them. The massive granite, some of the pegmatite, and the diabase are later than the metamorphism which formed the schists and are of course older than the planation of the region, which probably took place in Tertiary time. As has been stated, Paleozoic granite is not known in the South, and the granite and pegmatite are therefore probably pre-Cambrian. It has been shown on page 20 that the granite intrusion probably marked the end of the metamorphism; and this furnishes another evidence in favor of the belief that the great movements resulting in metamorphism took place in pre-Cambrian time. The porphyries and volcanic tuffs are likewise considered to be of pre-Cambrian age, appearing probably near the close of the metamorphism.

The diabase dikes are certainly the youngest of the igneous rocks, and have certainly escaped regional metamorphism, but more definite evidence as to their age was not obtained in this area. The writer is informed by the State geologist of South Carolina, Hon. Earle Sloan, that the diabase cuts Juratrias sediments and is probably of that age.

SEDIMENTARY ROCKS.

The comparatively small amount of induration, alteration, and contortion of the sediments occurring in the vicinity of Monroe, N. C., has already been described. It is difficult to believe that these soft rocks could have been present when metamorphism of the schists took place. On the other hand, they are older than the Triassic deposits of the "Newark" system. Fossils have not yet been found in the "Monroe" beds and their age remains a matter of uncertainty. The sands of the Coastal Plain formation which are included in this area are regarded by Doctor Sloan as probably belonging to the Columbia group of the Quaternary.

ECONOMIC GEOLOGY.

In the number of its mineral species North Carolina is said to excel any other State in the Union, and a great variety of minerals has been found in South Carolina. These minerals have long been prominent among the resources of the Carolinas, and the particular area described in this report has been one of the important localities in this respect.

Mining in this general region dates back before the time of the settling of America, and early Spanish and English accounts of the discovery and recovery of metals are numerous.[b] The principal mineral resource of this Carolina area is gold. Iron has been mined to a considerable extent, and within recent years the monazite industry has attained some importance. Tin is now creating considerable excitement. Besides these materials, copper, lead, manganese, pyrite, mica, barite, corundum, clay, limestone, and granite are or have been found and worked to a greater or less extent.

TIN.

The use of tin is steadily increasing and the demand for it is constantly growing. While new localities are being discovered from time to time, and while certain of the districts already known are increasing their output, some of the important tin-producing regions of the world are on the decline and others do not give promise of long maintaining their present

[a] Williams, G. H., Jour. Geol., vol. 2, 1894, pp. 28 et. seq. Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 260.

[b] Cf. Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 253-257.

production. The reserve stocks held in various parts of the world are accordingly being greatly depleted and the price of tin is gradually rising.

For these reasons the discovery of a new tin locality is of much interest to mining men, and to many who are more or less directly connected with the metal industry, as well as to investors. The fact that the United States consumes over 40 per cent of the world's output while contributing an inappreciable amount makes of especial interest any information regarding a tin locality within the borders of this country which gives the least promise of becoming economically important. Previous waves of excitement have arisen on several occasions, only to wane and finally die out because of the failure to demonstrate the presence of valuable tin deposits. South Dakota, Missouri, California, Virginia, and Alabama afford notable instances of this and the Carolina tin belt itself has once risen to prominence and then almost passed from memory. Within the past couple of years interest has been revived in this region and it is now attracting a good share of attention from the outside, while within the tin-bearing territory considerable excitement prevails.

It was mainly with the idea of studying these tin deposits and satisfying a demand for information concerning them that the reconnaissance of this region was undertaken. For this reason chiefly the description of the tin deposits is placed before that of the intrinsically more important product of the area, gold.

HISTORY OF TIN MINING IN THE CAROLINAS.

Tin was first mentioned in this region in 1875 by Kerr,[a] who stated that it occurred in a micaceous slate in Gaston County, associated with garnet and columnar topaz (pycnite).

The first authentic discovery of the metal was made some years later at the village of Kings Mountain, Gaston County, N. C. Mr. Robert T. Claywell, of Morganton, N. C., who is by all accredited with the first collection of specimens from this locality, communicated with the writer on this subject and the substance of his statements is here repeated. While a student at the Kings Mountain high school in 1881, Mr. Claywell found in a street of the town a number of pieces of a dark-colored mineral of noticeable specific gravity. Although he was an amateur student of mineralogy at that time, he was unable to identify this mineral. It appears that this mineral was added to a collection which he was making and remained unidentified for some time. In 1883, at the request of Col. S. McD. Tate, who was making a collection of North Carolina minerals for the American Exposition at Boston, this mineral collection, including the cassiterite, was sent to Boston. It is said by Mr. Claywell that this specimen before being sent was marked by Colonel Tate "Tin(?)."

So far as is known, the first published statement, aside from the one by Kerr, noted before, regarding tin in North Carolina, is said to have appeared in the Commercial Bulletin of Boston, October 13, 1883. In the list of minerals from North Carolina given in that issue occurred the following paragraph:

"Cassiterite, pure tin oxide. Found massive and semicrystallized in the western part of North Carolina. Sp. grav., 6.8; hardness, 7; 70 per cent tin."[b]

Mr. Hidden claims the credit of the identification of this mineral, and states that he labeled it;[c] the foregoing paragraph was obviously a copy of the label.

In an article dated February 14, 1884, Dr. C. W. Dabney, jr.,[d] stated that a specimen collected by Mr. Claywell was sent to him by Colonel Tate marked "No. —, tin?," but he does not tell when it was sent. He says, however, that he received other specimens in July, 1883, which also doubtless came indirectly from Mr. Claywell, and he visited Kings Mountain and instituted some explorations for the mineral. This is evidently the first signed article dealing with the discovery of the mineral. In a recent letter Doctor Dabney states that so far as he knows he was the first to identify Mr. Claywell's mineral as cassiterite.

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[a] Geology of North Carolina, 1875, p. 291.

[b] Hidden, W. E., Jour. Elisha Mitchell Sci. Soc., 1889, pt. 2, p. 66. The writer regrets that he has been unable to obtain this number of the Commercial Bulletin.

[c] Loc. cit. and personal letter to the writer.

[d] Science, vol. 3, February 22, 1884, p. 217; also Jour. Elisha Mitchell Sci. Soc., vol. 1, 1883–84, pp. 79–81.

The writer has endeavored to give here a plain statement of such facts as are available and to abstain from passing judgment on the question.

The news of the discovery of tin soon spread in Kings Mountain and throughout the country. Everyone in the town, men, women, and children, began to hunt for tin. All over the eastern part of the town they found crystals of cassiterite, which they sold as curios at 5 or 10 cents each. Early in 1885 a development company was formed by several prominent men of Kings Mountain and prospecting was begun. They read that tourmaline commonly accompanies tin, so they directed their attention to masses of tourmaline and black hornblende, which they encountered near the place where the float tin was found. Several pits were sunk and a 100-foot tunnel was driven south of the town, but no tin was found in place. The company disbanded and excitement subsided; but cassiterite crystals were still found in the streets of Kings Mountain.

In 1886 John H. Furman, a miner from Georgia, came to Kings Mountain to prospect for gold. He found bands of rock which he called "greisen," containing a black mineral supposed to be cassiterite. He took specimens of the material to Dr. A. R. Ledoux, of New York, who verified this supposition. Returning later under the direction of Ledoux, and with the assurance that the tin-bearing rock had at last been located, Furman began quietly to bond all the land which he considered promising. Prospecting was renewed on a broader scale; pits, trenches, shafts, and tunnels were started, and a considerable amount of ore was taken out for testing. At first small lots were sent to Ledoux's laboratories in New York, but it was found that samples of this kind were unreliable. Ledoux and Dr. James Douglass then came to the tin region, presumably in the interest of Phelps, Dodge & Co., of New York City. A stamp-mill test of 100 tons and returns from two carload lots of hand-picked ore shipped to England were fairly encouraging. In 1890 Furman sailed for England with specimens of ore and options on a large acreage in the hope of interesting capital there. The result of this mission is not known, but it was probably unsuccessful. An effort was next made by the Ledoux party to ascertain the extent of the ore bodies. The shafts were deepened and considerable diamond drilling was done. By these operations it was learned that the tin-bearing rocks were very irregular in extent and in their content of cassiterite, but the results were considered to justify the erection of a plant for treating the ore on the spot. A 10-stamp mill was erected about a mile and a half south of Kings Mountain station. After crushing, the ore passed through slatted sluices over burlap. Several tons of ore were tested at this plant, but the results were not gratifying, and work was stopped in the early nineties. It is said that clogging of the stamp mortars by the abundant mica of the tin-bearing rock and excessive loss of fine tin had more to do with the cessation of operations than a conclusive demonstration that the deposits were too small or of too low a grade to be profitable.

The work of this company had been directed mainly to the territory just south of the town of Kings Mountain. In the meantime other parties had been prospecting north of the town. Pits and shafts had been sunk and some machinery installed, but little or no success attended these efforts. By 1892 interest had abated, and very little work was being done.

About 1894 another company was formed, called the Kings Mountain Mineral and Development Company (Incorporated). The sum of $5,000 was raised by subscription and work was begun on Chestnut Ridge, a short distance northeast of the village of Kings Mountain. It was the intention to sink a shaft 150 feet deep and thus reach below the zone of decomposition. At a depth of 40 feet a crosscut from this shaft showed a decomposed "vein," holding considerable cassiterite, but it received no attention, since fresh rock only was being sought. Water was encountered in considerable amount, and the cost of pumping rapidly depleted the available funds, so that at a depth of 130 feet the capital was exhausted and work was stopped.

After this new failure an interval of several years witnessed only casual prospecting by M. M. Carpenter and A. R. Rudisill, of Kings Mountain, who had been connected with the

enterprise almost since its beginning and who had purchased or leased considerable land along the tin belt.

Interest was revived early in 1902, when Capt. S. S. Ross, of Gaffney, S. C., found cassiterite float on his farm 1½ miles northeast of Gaffney, considerably farther southwest than tin had been known before. The tin-bearing formation was located and found to contain a promising amount of the metal. The actual shipment of a carload of concentrates to England in 1903 brought the Ross mine into prominence and served to stimulate prospecting in other parts of the region. Carpenter and Rudisill again took up prospecting and soon sold what is now the Jones mine, near Bessemer City, to the Carolinas Tin and Development Company, of Gaffney, S. C. Early in 1904 this property was again sold to the present owners, the Carolina Tin Company, of Charlottesville, Va. In June, 1904, prospecting was undertaken by agents of the American Sheet and Tin Plate Company, who obtained options on about 5,000 acres for a sum reported to have been very large. Their attention was directed chiefly to Chestnut Ridge, northeast of Kings Mountain, and the Faires mine, just southwest of the village; but their operations appear not to have been sufficiently thorough or extensive to prove very much, and after several weeks they forfeited their options. During the late summer of 1904 the Jones, Ross, and Faires mines were being worked and active prospecting was going on in the northern part of Gaston County and in Lincoln County. In the fall the Faires mine was closed.

At the present time the Ross mine is in operation and Messrs. Carpenter and Rudisill are engaged in proving up their properties in the northern part of the area.

The history thus shows that tin mining in the Carolinas has been marked by a succession of failures ever since the discovery of cassiterite in 1881. It is hoped, however, that some of the operations at present under way will open a new page in this history upon which success shall be written.

GEOLOGY OF THE TIN BELT.

LOCATION.

The Carolina tin belt, as at present explored, extends from near Gaffney, Cherokee County, S. C., across parts of Cleveland and Gaston counties, N. C., to a point about 4 miles east of Lincolnton, Lincoln County, N. C., a distance of about 35 miles. In a general way it follows the Kings Mountain Range throughout that distance.

TIN-BEARING ROCKS.

From the discovery of tin-bearing rocks by Furman in 1886 until the present day cassiterite has been found in situ in this region only in dikes of pegmatite. The "greisen" of Furman[a] and Pratt,[b] the "feldspathic shale" of Sloan,[c] and the clay or kaolin in which the cassiterite occurs at the Ross mine are all in reality pegmatite. It is probable, also, that the term "feldspathic beds" of the writers before the existence of tin was known was applied to these pegmatite dikes.

DISTRIBUTION.

The position of the tin belt and the distribution and structure of the tin-bearing rocks are intimately connected with and dependent on the general geology of the area. In a preceding section (pp. 26–28) it has been shown that the country along the Kings Mountain Range is a belt of ancient metamorphic rocks folded into an anticline, invaded later by igneous rocks such as granite, pegmatite, and diabase, and then greatly eroded. It has also been shown that the pronounced structure of the metamorphic rocks exerted a marked influence on the distribution and structure of these later intrusives. The result of this influence has been that the invading rocks occur as sheet or dike-like bodies, whose upturned

[a] Trans. N. Y. Acad. Sci., vol. 8, 1888–89, p. 137.
[b] Mineral Resources U. S. for 1903, U. S. Geol. Survey, 1904 p. 340, or p. 10 of the extract entitled "The Production of Tin."
[c] The State, Columbia, S. C., August 22, 1904, p. 2.

edges furnish elongated outcrops, generally, though not everywhere, conforming in dip and strike with the surrounding schists.

Fig. 3. indicates the distribution of pegmatite, the tin-bearing rock. Passing through the northwestern part of Gaffney, S. C., the tin belt strikes about N. 60° E. to the vicinity of Kings Mountain station, N. C., thence turns more to the north (about N. 25° E.), and continues across Gaston County and into Lincoln County, about 4 miles east of Lincolnton, N. C. It thus corresponds closely with the axis of the Blacksburg fold; but the correspondence is not exact, for at Gaffney the pegmatite dikes occur on the southeast side of the axis and hence dip to the southeast, while from Blacksburg northward they occur where the rocks dip to the northwest, indicating that the belt crosses the axis of the fold at some intervening point. The relation of pegmatite to the structure of the metamorphic

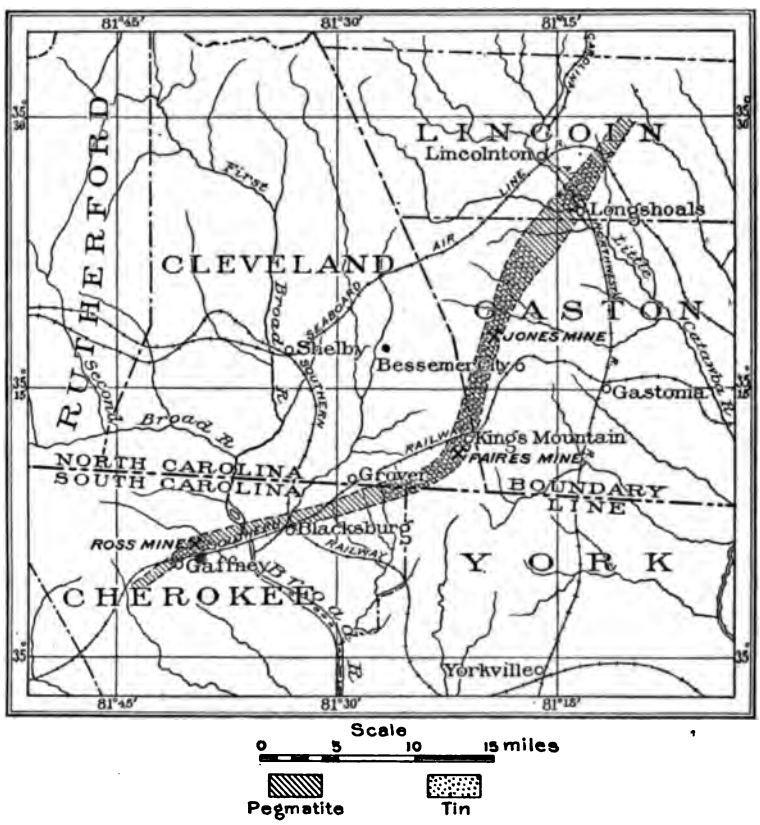


FIG. 3.—Sketch map showing distribution of pegmatite and tin in the Carolina belt.

rocks in the northern part of the area is not so readily discerned. The pegmatite belt is known to continue to the southwest beyond Gaffney and to the northeast beyond the center of Lincoln County, but authenticated discoveries of cassiterite have not been made outside of the limits mentioned. The width of this belt varies considerably; it comprises in some places a few narrow, closely spaced dikes, in others many dikes distributed over a belt as much as 2 miles wide. This maximum width is reached in the northern part of Gaston County.

STRUCTURE.

The masses of pegmatite range from numerous small streaks a few millimeters wide injected into the country rock, and collectively forming what may be considered a single

body, to bands probably 30 or more feet wide. One of the wider bodies occurs about a mile southeast of Kings Mountain village.

While conveniently designated as dikes, these masses are in many cases much more irregular than the form commonly implied by that name. In strike, dip, width, and extent individual bodies exhibit great variations. Forking or branching is rather common. Many of the dikes pinch out completely, in some places being succeeded by other lenses farther along in the same plane or in a near-by, parallel plane, while in others no continuation is found. These variations take place both horizontally and vertically. For instance, a dike which has a considerable continuous extent on the surface may pinch out at a comparatively small depth, perhaps to be found again directly below or at one side, or not at all. Conversely, a dike which is short horizontally may extend downward for a long distance without interruption. On the other hand, a few dikes appear to be fairly regular and persistent so far as explored, but some of these will probably exhibit irregularities at greater distance or depth.

A few exceptions to the general rule of conformity of the pegmatite dikes to the structure of the inclosing schists are worthy of notice. Exploration has not been sufficient to admit of very extended generalizations concerning most of the features of these tin deposits, and especially is this true in regard to structure, on which conclusions can be reached in no other way than by a large amount of development. Such observations as have already been made, however, point to the conclusion that those comparatively few dikes which fail to correspond in strike and dip with the surrounding rocks, but instead cut across the structure of the schists, are fairly persistent and regular.

An explanation of the irregularities of those dikes which conform with the foliation of the country rock might be found in the supposition that faulting or shearing had divided originally continuous bodies into a number of irregular masses and lenses. But the field evidence is against such a supposition. Slight faulting since the introduction of the pegmatite has occurred in some places, and some of the pegmatite shows that it has been subjected to very moderate crushing, but no great amount of movement can have taken place. Moreover, any faulting which would affect those dikes which parallel the schistosity would also affect the cross dikes; but the cross dikes are fairly regular and can not have suffered much dislocation.

One is therefore forced to the conclusion that these pegmatite masses owe their present form to the nature of the original cavities which they filled, or at least to that of the planes along which they forced their way and ascended. It will thus be necessary to consider the character and origin of these planes in arriving at an explanation of the forms which the pegmatite bodies possess.

We have here a region of rock beds of heterogeneous composition so folded that the form of any single bed may be likened to that of a piece of corrugated iron. This folding was produced by an enormous compressive stress acting during a long interval approximately at right angles to the axes of the corrugations or folds which were produced. The fold, however, is only the end product of a complicated process. To accomplish it there had to be movement among the beds and portions of the beds. This movement was a slipping or gliding, generally parallel to the bedding planes, and is evidenced to-day by the schistosity or foliation of the rocks. That these planes along which cohesion was overcome so that movement could take place are planes of weakness is proved by the cleavability of the rock along planes parallel to the schistosity. But, as may be seen from an examination of a specimen of these schists, the planes of weakness are not uniform; some are more prominent than others, and even the most prominent ones are irregular and not continuous, but instead give way to others which then themselves become prominent as such planes of weakness.

It thus appears that the directions or the loci of greatest weakness—those places which would determine the position and the form of intrusion—are not simple planes, but are instead comprised of series of parallel planes of irregular extent, arranged more or less stepwise, in some places branching, in others overlapping, and in still others almost separated by

the intervention of localities where the rock is stronger; *i. e.*, of greater cohesion between the two walls of the plane of movement.

Material forced by hydrostatic pressure from a reservoir below would follow these directions of weakness, force the walls apart, and occupy the space which it thus created for itself. Where cohesion had been entirely overcome by the original movement, the expansive force would be most effective, the intrusive material would have the greatest thickness, and the dike formed on solidification would have the greatest width. (See fig. 6, p. 50.)

The explanation of the irregular form of the pegmatite masses which conform to the schistosity of the inclosing rocks lies, therefore, in the fact that the planes along which intrusion or injection took place were themselves of irregular extent and their walls offered varying resistance to being forced apart by the invading material.

The explanation of the form of those dikes which cross the structure of the surrounding rocks is somewhat different, just as their form is different. After the rocks of this region had been folded to their present structure and the forces which caused this folding had nearly or quite subsided new forces more or less transverse to the first became active. These new forces tended to produce folds transverse to those already existing. But the resistance of this folded belt to contortion across the strike was too great to be overcome, just as corrugated iron is rigid to deformation at right angles to the corrugations. Since the stress induced by these later forces could not be relieved by folding, fracture at right angles to the direction of force took place. This fracturing was sufficient to relieve the stress and little faulting or other movement followed.

Later, when the material of the pegmatite dikes began to exert pressure on the walls of its reservoir, it found, besides those irregular places of weakness parallel to the foliation of the rocks already described, definite, sharp fractures or cracks, offering a fairly uniform resistance to the passage of a fluid and hence capable of being expanded and filled fairly evenly throughout their extent. These cross dikes are in consequence regular and persistent. In some instances relatively small branches or offshoots from the main cross dike are injected into the wall rock parallel to its schistosity. This adds to the evidence that although the cross dikes occupy fissures of later formation than those filled by the interfoliated dikes, the two classes of dikes are contemporaneous. (Compare fig. 5, p. 47, and fig. 6, p. 50.)

From these considerations the conclusion may be deduced that in the exploitation of a dike which crosses the foliation of the inclosing rock the prospector, while proceeding by those cautious methods which should always attend the early development of a mining region, may reasonably expect to find the dike continuous and possessing a fair degree of regularity. In the case of the dike parallel to the structure of the country rock, however, he must be prepared to meet great and sudden variations in its form and position; but if he explores beyond the limits of one lens he may often be rewarded by the discovery of another.

So far as known at present, faulting has not been sufficient to affect in any important degree the position or extent of these dikes.

DESCRIPTION AND MINERALOGY.

The tin-bearing rocks embrace two of the varieties of pegmatite described on pages 20–22. As was there stated, these two varieties, the third and fourth, may be simply different facies of the same rock. At any rate, it is highly probable that they do not differ greatly in composition. The general petrographic descriptions of these rocks have already been given. It will here be appropriate to consider them more in detail and in the light of ore-bearing formations.

The third or microcline variety of pegmatite was at first thought not to contain cassiterite,[a] but recent developments at the Ross mine below the zone of extreme decomposition have shown that this rock is the one which carries the cassiterite. In several places in

[a] Bull. U. S. Geol. Survey No. 260, 1905, p. 191.

that mine the pegmatite is very much like granite in appearance, and there the cassiterite is in small grains and less abundant than where the rock is coarser. Mica is not an abundant constituent, but is present locally, probably representing a transition to the fourth variety, which is in general characterized by much muscovite and little feldspar. A little hornblende has been found. On weathering this microcline pegmatite becomes very soft and clay-like, owing to the change of the feldspar into kaolin.

The fourth variety of pegmatite is much more interesting mineralogically. While consisting generally of abundant quartz and large flakes of muscovite mica, with a small amount of orthoclase, microcline, and albite or oligoclase-albite, some of it varies decidedly from such a mineralogical composition. In places it contains little mica and much feldspar. The muscovite has been called a fluoric mica,[a] but an analysis by Mr. W. T. Schaller of typical muscovite from the Jones mine gave only 0.15 per cent fluorine, which is rather below the average amount for muscovite. It is generally colorless, but yellowish or light-green colors are not unusual. Some of the flakes are several centimeters across. In some of the dikes which contain other lithium minerals the muscovite is bordered by an extremely narrow zone of lepidolite or lithia mica. In no other case has lepidolite been found.

Spodumene, the lithium-aluminum silicate, is not uncommonly present, and in some dikes, particularly those rich in feldspar, constitutes a considerable proportion of the rock. It occurs in large and small individuals devoid of crystal outline but having well-developed cleavages intersecting at 93°. It is colorless to white and in some individuals has a silky luster. Under the microscope the mineral is perfectly clear and colorless. The index of refraction is rather high. The double refraction is probably not over 0.020. Extinction is inclined to the traces of cleavage in some sections and the maximum extinction angle observed was $c : \dot{c} = 24°$. The mineral is biaxial and positive. Before the blowpipe it fuses and gives a strong flame test for lithium.

A yellowish-brown mineral occurring at the Faires mine contains lithium, manganese, phosphoric acid, and probably iron, and is undoubtedly lithiophilite. Where it has been subjected to decomposition near the surface—that is, to hydration and oxidation—it is converted into a black or brownish-black material of pitchy luster and conchoidal fracture, which contains iron, manganese, phosphoric acid, and water, and is probably a definite mineral. In close association with the lithiophilite, occupying lenses and veinlets and in one specimen, occurring between the lithiophilite and its black oxidation product, is a purple mineral which has been found to be a new species and has been named purpurite.[b] The occurrence of this mineral indicates that it is a decomposition product of lithiophilite, and its chemical composition confirms this view. It is a hydrous manganic ferric phosphate of the formula $2\,[(Mn''', Fe''')\,PO_4]\,H_2O$, and is the only known case of a manganic phosphate.

The mineral is probably orthorhombic, but crystal outline has in no case been observed. Two cleavages, presumably at right angles and pinacoidal, are of unequal perfection. The cleavage surfaces are in many grains somewhat curved, as if adjacent particles of the mineral did not possess exactly the same orientation. It has an uneven fracture and is rather brittle. Its hardness is 4–4.5 and specific gravity about 3.15. In color the mineral is a rich deep red or reddish purple, and the powder and streak have a decided purple or deep-rose color.

Although purpurite is transparent in exceedingly thin pieces, giving beautiful red colors, the ordinary thin section of the mineral allows the passage of very little light. Parallel to the cleavage the color is a deep scarlet, inclining to rose-red, while across the cleavage the absorption is greater and the color becomes a rich purple. Extinction is generally parallel; an inclination up to 3° or 4° which has been observed in a few instances has probably been due to the orientation of the sections examined. It may be, however, that the mineral is monoclinic, with a very small extinction angle. It was impossible to obtain an interference

[a] Pratt, J. H., and Sterrett, D. B., Bull. North Carolina Geol. Survey No. 19, 1904, p. 48.
[b] Graton, L. C., and Schaller, W. T., Am. Jour. Sci., 4th ser., vol. 20, 1905, pp. 146–151.

figure on the material available. If the mineral is biaxial, as is probably the case, the intersection of the cleavages is parallel to a. This is also the direction of least absorption. The refractive index is probably between 1.60 and 1.65. The double refraction is high, probably in the neighborhood of 0.060. Analyses by W. T. Schaller gave the following average composition for purpurite:

Average analysis of purpurite.

Fe_2O_3	15.89
Mn_2O_3	29.25
P_2O_5	47.30
H_2O at 100°	3.31
H^2O above 100°	1.95
CaO	1.48
Na_2O	.84
Li_2O	Trace.
Insoluble	.52
	100.54

It is probable that the soda and lime exist as impurities, or inclusions of foreign material, in the mineral. The lithia is doubtless a remnant of that of the lithiophilite.

Black manganese oxide, probably also derived from the decomposition of lithiophilite, is present in many places as thin botryoidal coatings on the other minerals. Some apatite occurs in narrow vein-like masses of bluish color and was at first thought to be fluorite. In isolated crystals of small size it has a bright-green color.

The cassiterite, the constituent of these rocks which is important from the economic standpoint, may better be described under the head of the ores (pp. 41–42). In thin section under the microscope it is found to include, besides tiny flakes of hematite, numerous minute dark grains which resemble black iron ore. The fact that a carefully panned sample of tin concentrates gave Doctor Hillebrand decided reactions for iron and titanium indicates that this material is ilmenite. Wolframite has been reported as accompanying the cassiterite, but careful search has failed to reveal its presence. It ought readily to be distinguished in the pan by its dark color, even in fine powder, its good cleavage, and its specific gravity, which is greater than that of cassiterite. It seems probable that the tungstic oxide reported in early analyses[a] of Carolina cassiterite may have been confused with the rarer elements columbium or tantalum, which have been found recently, although it may be that tungsten does in some cases exist as wolframite, but included within the grains of cassiterite, as is the ilmenite.

Chalcopyrite[b] and arsenopyrite,[c] or mispickel, have also been reported from the pegmatites, but it is doubtful if they occur as original constituents of these rocks.

CONTACT METAMORPHISM.

A general idea of the changes induced in the surrounding rocks by the intrusion of pegmatite has already been given. A study of this metamorphism is, of course, futile in the zone of surficial decomposition. Unfortunately, at the only place along the belt where development has extended into the unaltered rock (the Jones mine), a dike of granite or aplite is in close connection with the pegmatite. The granite is probably older than the pegmatite and the changes at its contact have certainly been more intense. Its effect has therefore partly forestalled and partly overshadowed that of the pegmatite. The development of clear brown biotite and less commonly of garnet and pyrite in the amphibolite can in some places, however, be seen to result from the action of the pegmatite.

Quartz veins closely associated with dikes of both granite and pegmatite exhibit very remarkable metasomatic alteration in the adjoining rocks. These veins vary in width from

[a] Cf. Dabney, C. W., jr., Jour. Elisha Mitchell Sci. Soc., 1883–84, p. 81.
[b] Furman, J. H., Trans. New York Acad. Sci., vol. 8, 1889, p. 144.
[c] Ledoux, A. R., Eng. and Min. Jour., vol. 48, 1889, p. 521.

the merest stringers to several feet, and the metamorphic action of even the smallest is intense. The quartz of the veins is rather finely granular and under the microscope the grains are found to interlock in the manner characteristic of the granitic texture of igneous rocks. Small, many-sided prisms of deep-brown tourmaline occur scattered and in bunches through the quartz. In thin section the zonal structure of these crystals is readily seen. The interior is usually pleochroic in blue and violet colors, while the exterior is brown. Flattened individuals of ilmenite are in some places abundant. Sulphides, of which pyrite is most common, but including also pyrrhotite and chalcopyrite and perhaps a little arsenopyrite, are common though not abundant constituents in certain of the veins. In many instances the various sulphides are intergrown. Careful assays have shown that some of these veins carry gold. Further reference to this subject is made on pages 69–70.

The metasomatic processes which these veins have induced in their walls resemble as closely those of igneous masses as they do those of fissure veins. The formation in the country rock of garnet, brown biotite, and probably some magnetite might be attributed to contact metamorphism, while the impregnation with sulphides and quartz is more closely related to vein action. Tourmaline is common to both.

These veins are later than either the aplitic or the pegmatite dikes, and induce in them changes which are somewhat similar to those caused in amphibolite. In the granite or aplite the tourmaline has so nicely replaced feldspar[a] that it might easily be mistaken for an original constituent of the rock.

The texture and mineral constituents of these veins and their effect on their walls indicate that they were formed at great depth, and their intimate association with the granite and pegmatite shows almost beyond question that they are genetically related to those rocks.

TIN DEPOSITS.

It may be well to state at this point that the tin deposits of the Carolinas can in no way be considered veins. They are, instead, dikes of an igneous rock—pegmatite—which have solidified from an originally molten state. Placer deposits of comparatively little importance have been derived from the breaking down of these dikes.

DISTRIBUTION OF CASSITERITE IN THE DIKES.

The tin-bearing mineral is an exceedingly variable constituent of the pegmatite. Probably in the majority of cases where pegmatite has been found no cassitertite can be seen in it, and while it is possible that the mineral is generally disseminated in minute grains throughout the rock, such is probably not the case. On the other hand, certain bodies or portions of bodies of pegmatite contain a very large proportion of cassiterite, and some masses weighing several hundred pounds are made up almost wholly of cassiterite. There are all gradations between these limits. While the distribution of the tin mineral is thus very irregular, there is in most cases a certain system in this irregularity. The tin is usually concentrated along certain lines or zones, which thus constitute ore shoots. These ore shoots also are irregular, something after the manner of the dikes themselves. They pinch and swell, branch, die out, and reappear in an erratic way. Nevertheless, the determination of the presence and direction of an ore shoot is a great aid to development. "Pockets"

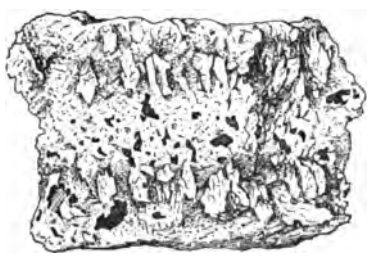


FIG. 4.—Sketch of narrow pegmatite dike, showing distribution of cassiterite. Natural size.

[a] Cf. Lindgren, W., Genesis of Ore Deposits, New York, 1904, p. 533.

of tin ore are usually found to be simply lens-like portions of an ore shoot that are of especial width or richness. Development has not yet been sufficiently extensive to show whether or not there is any regularity in the position of these shoots in the dikes. They have as a rule a much elongated form, measuring only a few feet along the dike at a right angle to their greatest dimension. Some of the ore bodies, however, have a considerable extent in two directions and a few of them persist as far as present explorations have gone. In general they pitch steeply, though the angle of pitch may vary in the same shoot. In some places there seems to be a tendency for the shoot to occupy the full width of the dike, while in others it is confined to one side or the other or to the middle of the dike. Fig. 4 illustrates concentration near the middle of a narrow dike.

THE ORES.

The principal tin-bearing mineral in nearly all the tin-producing regions of the world is cassiterite, the dioxide SnO_2. This is the only tin mineral known to occur in the Carolina region. It is present in the pegmatite dikes in sizes ranging from tiny grains, barely visible to the unaided eye, to individuals weighing as much as 2 pounds. The mineral is crystalline, but only rarely possesses crystallographic outline. Where crystal faces are developed they are uniformly those of the low unit pyramid. Twinning is rather common, as shown both by the form of the crystals and by the behavior of sections under the microscope. An imperfect cleavage parallel to the prism face is often observed. Owing both to this cleavage and to some peculiarity of crystal development, many individuals of cassiterite are flattened. The fracture is uneven. The mineral is extremely brittle and friable, particularly where occurring near the surface, and on this account seems in many cases much lower in the scale of hardness than its actual value of 6–7. On account of its relatively high specific gravity, 6.8 to 7.1, it is rather easily separated by panning or other means of gravity concentration from most or all of the minerals which ordinarily accompany it. The color of the Carolina cassiterite is in most cases very dark, ranging from deep brown to black. Lighter colored or even colorless varieties have been reported, but none have been seen by the writer. The brown specimens have a resinous appearance; the blacker ones show a metallic luster. The streak and the powder range in color, depending on the intensity of color of the specimen, from nearly white to chocolate brown, and are in no case black. This fact serves to distinguish cassiterite from many minerals of similar appearance which occur in and about the tin region. Owing to the presence of included impurities which can not be mechanically separated, the Carolina cassiterite falls somewhat below the theoretical content of 78.6 per cent metallic tin. Probably 74 to 75 per cent would be an average for the carefully selected material.

In thin section the cassiterite generally gives evidence of imperfect crystal form, and in some specimens the effect of twinning is shown in the outline. Twinning is parallel to the pyramidal face (1, 1, 1) and is in some individuals repeated polysynthetically. Prismatic cleavage is readily discernable in some instances, and indication of a second cleavage parallel to the pyramid has been seen. The mineral is usually deeply colored, but the distribution of the color is uneven, giving a flaky or patchy appearance. The color is probably due to the solution, in the cassiterite, of a small amount of an iron mineral, possibly hematite, since the deeper-colored varities carry most iron. Dichroism is decided. The common absorptions are ε=deep red or red-brown, ω=light yellowish brown to nearly colorless. Sometimes ε= coffee brown, ω= bluish green. The refractive index and the double refraction are characteristically high. Some minute included flakes of hematite and grains of ilmenite are visible. Partial analyses[a] of specimens of cassiterite from Kings Mountain made in 1883 indicated the presence of about 1 per cent of tungstic oxide. A qualitative analysis of concentrates from the northern part of the tin belt, made by Dr. W. F. Hillebrand, fails to show the presence of tungsten, but reveals an appreciable amount

[a] Dabney, C. W., jr., Jour. Elisha Mitchell Sci. Soc., 1883–84, p. 81.

of columbium, with possibly some tantalum. It is probable that these rare elements were confused with tungsten in the early analyses.

The material which is mined as tin ore consists of the pegmatite rock, with its content of cassiterite. Within the limits of the ore shoots this mineral is in general fairly evenly distributed through the rock. Pl. III, *A*, reproduces a photograph of a specimen from the Henry Carpenter property near Long Shoals, Lincoln County, and gives a good idea of the common appearance of the ore. The black spots are the cassiterite. This particular specimen is rather rich, containing probably 10 per cent of cassiterite, which corresponds to about 7 per cent of metallic tin. Pl. III, *B*, is a photomicrograph of this ore. In a small dike in the Faires mine near the village of Kings Mountain the cassiterite is distributed as shown in fig. 4. The dark portion is cassiterite and the larger light areas are muscovite, the remainder being a finely granular mixture of quartz, muscovite, and a little feldspar. In the quartz-muscovite variety of pegmatite, cassiterite seems to be more common in the mica-rich rocks than in those which contain more feldspar. Very little tin has been found in the spodumene-bearing dikes.

Much of the ore from depths to which superficial alteration has barely extended is coated along cracks and seams with black manganese oxide, probably pyrolusite, which has doubtless resulted from the decomposition of lithiophilite. This manganese mineral is in many places deposited on and between the foils of the muscovite. It is scattered in patches over the surface of the ore, and when viewed at some distance is easily mistaken for cassiterite. The quartz-mica pegmatite is stained somewhat brown on weathering and becomes more friable. The microcline pegmatite readily decomposes into a white, soft kaolin, containing small gritty grains of quartz. In this soft matrix the cassiterite remains practically unchanged and can easily be picked out with the fingers. Some crystals thus obtained have a roughened surface, as if they had been slightly etched. Whether this is actually the explanation or not is unknown.

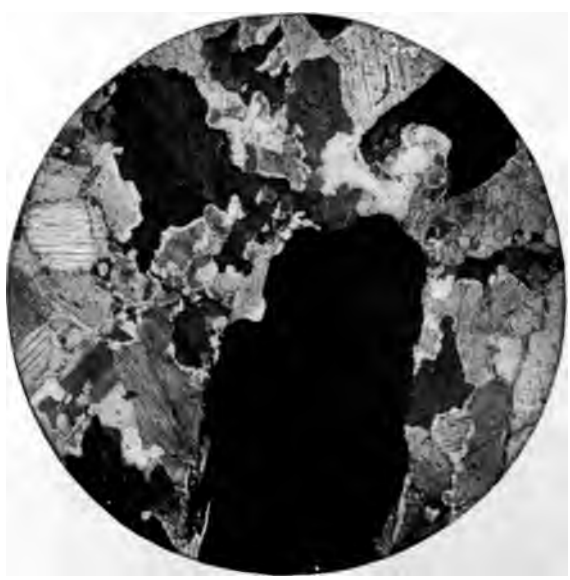
GENESIS OF THE DEPOSITS.

From the standpoint of the geologist the point which is perhaps of greatest interest concerning the ore deposits of a region is their origin. To the miner as well this subject should be of interest, since it is of great importance. An understanding of the manner in which the ore was formed and reached its present position is almost certain to throw light on its probable richness in unexplored places, the probability of its continuing with depth, and other vital questions which confront the mining man in the development of a new region.

Throughout the world the most common occurrence of lode tin, that is, tin ore mined from the rock in place, is in veins, which usually cut granitic rocks. These veins generally have a gangue of quartz and are characterized by the presence of fluorine, boron, tungsten, lithium, and arsenic minerals associated with the cassiterite. Prominent among these minerals are topaz, fluorite, tourmaline, wolframite, scheelite, lepidolite, zinnwaldite, and arsenopyrite. These materials are regarded as representing the final emanations from the granitic magmas. It is supposed that these comparatively rare elements are more and more segregated and concentrated as the solidification of the granite goes on, and at last, when fissures form, they are carried up in the form of vapors and solutions at high temperature and are deposited with quartz in the veins. Although these are usually veins of filling, occupying fissures or crevices, alteration and metasomatic replacement of the wall rock has in nearly all cases been considerable. The quartz of the granite has been little affected, but the feldspar and mica have been attacked, being partially converted into a mica which is usually lithia bearing, either lepidolite or zinnwaldite, and partially replaced by one or more of the foregoing minerals and by cassiterite. The resulting rock, composed largely of quartz and mica, is designated greisen. This term can never be applied to any but an altered rock, a product of this particular kind of vein metamorphism.

In contrast with this usual occurrence of tin in veins is the occurrence of cassiterite as a primary or original mineral of igneous rocks, usually pegmatite. Tin has thus been found in pegmatite in the Vegetable Creek district of New South Wales and in the Black Hills of

A. SPECIMEN OF TIN-BEARING PEGMATITE.



B. PHOTOMICROGRAPH OF TIN ORE FROM THE JONES MINE.

Showing the dark cassiterite as a constituent of the quartz-mica pegmatite. Magnified 20 diameters.

South Dakota. Because of the unusualness of this mode of occurrence, tin deposits of this type have not been so thoroughly studied as the vein deposits. At many places the pegmatite dikes carry, besides the tin mineral, compounds of lithium and of phosphorus, such as spodumene, lepidolite, apatite, triphylite, and autunite. In these cases the cassiterite has crystallized along with or a little earlier than most of the other constituents. The pegmatite, being a product of solidification of molten material, is sharply defined from its walls, and in no case does the cassiterite replace portions of the country rock. On the other hand, the pegmatite produces at its contact metamorphism of the same kind as that produced by granite. Garnet is a rather common product in the wall rock; locally tourmaline is introduced and a chestnut-brown mica is developed in many places.

As in the case of the tin-bearing veins, these pegmatite dikes likewise are regarded as one of the final products from the granite magma, being succeeded only by vein formation. Like the veins, the dikes represent a concentration of those rare elements and the water which has been gradually excluded by the crystallization of the main body of the rock. In many respects, therefore, these two modes of occurrence are closely related.

Turning now to a consideration of the Carolina tin deposits, we find it evident at once that they belong to the second class, with cassiterite as an original constituent of pegmatite. In a preceding section (p. 22) it has been shown that the pegmatite dikes of this region are almost unquestionably related in origin to the granite and granitic gneiss which occur with some interruption all along the tin belt. Below the zone of surface decomposition these masses of tin-bearing rock exist in the same condition in which they originally solidified from the magma; they have suffered no alteration; they are not greisen. The effect of these dikes on the surrounding rock is characteristic not of veins but of igneous intrusions. Careful search for cassiterite in the wall rock has been made both by crushing and panning and by microscopic examination of thin sections, and in no case has tin been found, nor has it ever been reported as occurring outside of the dike proper. The absence of tourmaline, topaz, and wolframite and the extremely small amount of lithia mica in the tin-bearing rock, while, on the other hand, spodumene, lithiophilite, and apatite are present, go far in support of the view that the tin is of igneous origin. In one case a crystal of cassiterite was found adjoining a large crystal of orthoclase that is perfectly unaltered except for a slight amount of weathering. Such an occurrence would be extremely unlikely if the cassiterite had been deposited by replacement from solutions.

The unequal distribution of the cassiterite in the dikes is a subject difficult of explanation. Some combination of conditions or some process of differentiation as yet unknown has doubtless caused the segregation of tin in the ore shoots. A process of probably a similar nature has resulted in the formation of relatively large masses of quartz and of feldspar in the dikes, such as are seen in the Faires mine.

The complete cycle, beginning with granitic intrusion, followed by pegmatite intrusion, and brought to a close by vein formation, has been followed out in the Carolina region. The veins are closely associated with the pegmatites and in some cases with dikes of granite or aplite. They are quartz veins carrying pyrite, ilmenite, and in many places abundant tourmaline. Some of them, at least, carry gold. (See pp. 69–70.) Their walls also are in many places impregnated with tourmaline. They are usually parallel with and a short distance away from the pegmatite. In no place have they been found actually cutting the pegmatite, but at the Ross mine some of the pegmatite contains secondary tourmaline which was probably derived from one of these veins.

As has been previously stated (p. 40) these veins give evidence of having been formed at great depth and high temperature. It is probable that if the pegmatite had not been expelled from the magma reservoir, or had not carried all the tin with it, these veins would have received the tin of the magma, forming tin veins like those of most other tin deposits.

To summarize the origin of these tin deposits, pegmatite dikes genetically related to bodies of granite contain cassiterite as an original constituent unevenly distributed throughout their mass. The cassiterite was formed at practically the same time as the quartz, mica, feldspar, and other minerals of the dikes by crystallizing from the molten pegmatite magma.

In former descriptions of the Carolina tin deposits reference has often been made to the fact that the strike of the tin belt, if prolonged, would just about pass through the tin locality of Rockbridge County, Va., and from this single fact some have gone as far as to state that the two deposits are probably related. Largely with the idea of testing the correctness of this view, the writer visited the Virginia locality. Owing to lack of time and the fact that no work has been done at this place for a number of years, a thoroughly satisfactory idea of the deposits at the Cash mine was not obtained. But this much may be said. Cassiterite occurs there in quartz veins cutting a coarse granite. The veins are well banded and contain, besides cassiterite, bands of pyrite and arsenopyrite. The granite walls are converted into greisen, being composed of quartz, fine scaly muscovite, and a small amount of cassiterite.

From the standpoint of mode of occurrence and genesis, therefore, the Virginia and Carolina deposits have almost nothing in common. Moreover, the geologic instead of geometric continuation of the Carolina tin belt passes far to the east of the Virginia deposits.

AGE OF THE DEPOSITS.

Since the granite and pegmatite are considered to be of pre-Cambrian age, the tin deposits are likewise pre-Cambrian. They have therefore been subjected to the various agencies of disintegration and decomposition through an enormous length of time.

PLACERS.

The first cassiterite discovered in the Carolina region occurred as loose pieces unattached to any rock in place, and during the first five years that the existence of tin was known nothing but this float tin was found. Since the discovery of cassiterite in the rock in place nearly all prospecting and primary development work has been guided by the occurrence of pieces of float. In a few places, as at the Ross mine and the Jones mine, the amount of cassiterite scattered through the soil has been sufficient to encourage efforts for its recovery, and a comparatively small return has been obtained. A little panning has been done in the beds and flood plains of some of the streams, but the results have not been promising.

All this float or placer tin is directly traceable to the original deposits in dikes. As the rocks are decomposed and disintegrated, the cassiterite of the dikes, being very resistant to alteration, is freed from the rock and on removal of the other materials is left behind because of its high specific gravity, being in this way gradually concentrated.

It is known that since the formation of the tin deposits this region has been subjected to extreme degradation. All the phenomena of intrusion, contact metamorphism, and vein formation which have here been observed point to the fact that these porcesses went on under great pressure and therefore far below what was then the surface. The physiographic evidence in the planation of this much-folded region is in the same direction. It thus appears that extensive portions of the tin-bearing dikes have been removed. Much cassiterite must thus have been liberated from the rock and remained close to the original ore bodies as placer deposits. It is probable that more thorough prospecting of stream gravels along the tin belt will result in the discovery of small amounts of the mineral; but such search as has been conducted leads one not to expect the presence of extensive placers. The question then arises as to what has become of the large amount of tin which must have resulted from the disintegration and degradation of the tin-bearing rocks. It is believed that the answer to this question lies mainly in the fact that the cassiterite has been dissolved and thus carried away.

While from the customary standpoint of the laboratory chemist cassiterite is pronounced insoluble, it nevertheless does dissolve very slowly, even in pure water.[a] The oft-cited case of pseudomorphic replacement by cassiterite of the material of deer horns [b] shows that in a comparatively short interval of geologic time marked solution will take place. It

[a] Doelter, C., Tschermaks Min. u. petrogr. Mittheilungen, vol. 11, p. 325.
[b] Collins, J. H., Trans. Roy. Geog. Soc. Cornwall, vol. 10, pp. 98–100.

seems probable that, subjected to the action of solutions during long geologic ages, the cassiterite may have been in great part dissolved and carried away in the streams. It is not unlikely that the peculiar conditions existing when the country was reduced almost to base-level had much to do with this result. The streams, then being sluggish, could dissolve greater amounts of chemical substances and thus become more powerful reagents than under ordinary conditions, and it is easily conceivable that under these circumstances the cassiterite was dissolved at a comparatively rapid rate.

It has been sought to test this hypothesis by examination of individuals of cassiterite in the upper part of deeply decomposed dikes to see if they have suffered any etching or solution. The almost complete absence of smooth crystal faces and the uneven but not very rough surfaces of the grains have made it impossible to decide this question with certainty, but it seems probable that some solution has taken place.[a] The increased friability of the mineral near the surface may be some indication of solution along cleavages or minute cracks. Furthermore, this very friability may have aided in the removal of the tin, both by exposing greater surfaces and in this way hastening solution and by subjecting the larger grains to comminution under moderate impact and thus allowing stream transportation of the fine particles.

According to this explanation the float tin which has been found must be of comparatively recent derivation. Such seems certainly to be the case. No cassiterite is known at any great distance from deposits in place, and that which has been found is usually rough and angular, often found adhering to pieces of the pegmatite rock, indicating that it has been transported only a short distance, and that little decomposition has taken place.

In spite of these conclusions, more systematic and extended search for stream tin is advocated. Prospecting by means of the pan is so easily and cheaply accomplished, and winning of tin from placer deposits is so much less expensive than from veins, that a moderate expenditure in search of such deposits seems to be worth the risk.

CONCLUSIONS.

From the foregoing remarks on the placers and the genesis of the ore, it is possible to draw certain conclusions which may be of interest and value to those engaged in the exploitation of these deposits. It has been shown that the present surface is, relative to the rocks, far below the surface existing when the pegmatite intrusions occurred and hence exposes portions of the ore bodies which were formed only at great depth. In other words, the deposition of the ore now found is in no way related to the present surface and probably was only remotely connected with the original surface. No solution of the tin from upper parts of the deposits and redeposition in lower parts—the phenomenon known as secondary enrichment—has taken place. The igneous origin of the ore and the fact that the deposits now known were themselves deep seated unite with the foregoing facts to establish the prediction that the deposits will probably maintain their present characters and richness beyond the depth to which economic mining is now possible.

MINING DEVELOPMENTS.

LOCALITIES.

A condensed account of early development operations in the Carolina tin belt has been given in the section devoted to history (pp. 32–34). Time was not available for a careful examination throughout the tin belt and attention was directed chiefly to those places where a considerable amount of development work has been done. For the sake of completeness, however, a list of properties on which tin is known to have been found is given here. A more extended account of some of these occurrences is given in Pratt and Sterrett's bulletin on the Carolina tin deposits.[b] Prospecting has been rewarded by the discovery of cassiterite float at the localities or on the properties of the persons named in the following

[a] Cf. p. 42.
[b] Bull. North Carolina Geol. Survey No. 19, 1904, pp. 22–30.

list, beginning at the southwest: Capt. S. S. Ross, B. O. Jenkins, R. Patterson, Eph. Jackson, John Kester, V. Hambright, George Patterson, Dr. J. G. Horde, J. M. Smith, W. O. Ware, E. C. Faires, I. B. Falls, Mrs. Lizzie Falls, the streets and lots of Kings Mountain, Carpenter and Rudisill, J. J. Ormond, Arrowwood Brothers, R. A. White, M. V. Hovis, Ramseur Mill tract, John E. Jones, Mr. Weaver, Charles Byers, A. J. Rayfield, Sylvanus Beam, William Broom, William Carpenter, Sam Gardner, Katherine Vickers, Philip and Christy Jenkins, Norah Rayfield, John Carpenter, Eli Mosteller, Henry Carpenter, Monroe Reep, and Eph. Carpenter. A break in the general continuity of known localities occurs between the Ross property near Gaffney and the B. O. Jenkins place, about 1½ miles northeast of Grover, a distance of about 12 miles, although, as reported, a fragment of cassiterite has been found in pegmatite on the place of William Martin, about 3½ miles northwest of Blacksburg, near the State line. Another break about 3 miles long occurs just south of Little Catawba River in the northern part of Gaston County. Pegmatite is found all along these intervals, however, and further search may reveal the presence of cassiterite.

DESCRIPTION OF MINES AND PROSPECTS.

Recent operations of anything more than a preliminary character have been carried on at only three places. These are the Jones, Faires, and Ross mines. Considerable prospecting in the way of trenches and pits has been done by Messrs. Carpenter and Rudisill in the northern part of the belt.[a]

JONES MINE.

The property known as the Jones mine, which was a part of the John E. Jones plantation, is situated about 7 miles north-northeast of Kings Mountain and about 3 miles northwest of Bessemer City, stations on the Southern Railway. The mine is owned and operated by the Carolina Tin Company, of Charlottesville, Va. Some work was done at this place before the recent activity in tin mining, and several shallow workings have been encountered, which probably date back to 1892 or 1893. In 1903 development was begun by the Carolinas Tin and Development Company, which held the property under option. Early in 1904 it was sold to the present owners, who have done the greater part of the work. About a carload of concentrates has been obtained from the ore thus far mined and milled, and one small trial shipment has been made.

The surface developments include a shaft house, boiler, and hoist. A mill for the extraction of the cassiterite from the ore has also been erected. The workings consist of a vertical shaft 175 feet deep, with levels at depths of 50, 100, and 150 feet, aggregating, perhaps, 500 feet of underground development. The 50-foot level connects with the bottom of a shaft a short distance to the east of the main shaft. A few hundred feet to the south are a shallow pit and short drift.

The country rock of this mine is the typical amphibolite of the region and has a foliation which strikes about N. 30° E. and dips about 50° to 60° NW. Cutting this amphibolite is a dike of granite or aplite 2 or 3 feet wide and irregular, like the interfoliated bodies of pegmatite. Two dikes of pegmatite are also intruded into the amphibolite. One, parallel to the foliation, lies near and southeast of the granite dike. The other, which has been traced on the surface for 1,000 feet, cuts across the structure of the country, striking N. 78° W. and dipping very steeply to the south. It is not yet definitely known whether these two dikes unite or whether one cuts the other, but there is reason to believe that they are of the same age and do unite. While the evidence is not wholly satisfactory, the cross dike of pegmatite appears to cut the granite dike. This aplite or granite produces metamorphism at its contact like that described in detail on pages 24 and 25. The pegmatite also alters the adjoining amphibolite. Close to the aplite a narrow veinlet of quartz, which carries a small amount of gold, impregnates the surrounding rocks with tourmaline, garnet,

[a] The writer has recently been informed that active work, attended with gratifying results, is being carried on in this northern part of the district; and that considerable development work is being done by a new company just north of the village of Kings Mountain.

and magnetite. There are present, then, in this mine representatives of the three stages of the intrusion of granite. On this account, as well as for the reason that the workings have reached below the zone of superficial alteration, the Jones mine is the most interesting and instructive place in the entire belt for the study of the tin deposits.

The pegmatite of the Jones mine is the quartz-muscovite variety, in general coarse grained, but in certain places rather finely granular. The mica is usually a prominent constituent. Both dikes contain cassiterite. A shallow pit and short drift on the interfoliated or inclined dike exposes a narrow shoot of ore pitching not very steeply to the northeast, so that it passes below the drift.

The principal workings are on the cross dike. The main shaft begins on the dike, but at some depth the dike bends to the south and the dike passes into the foot wall. It is estimated that the bottom of the shaft is at least 20 feet distant from the dike.

Although varying in width from a few inches to 4 feet, and having a strike and dip which are not exactly constant, this dike is regular as compared with the majority of pegmatite bodies of the region. Fig. 5 gives an indication of the structure of this dike. Little narrow offshoots are injected into the country rock parallel to its foliation. Slickensides are seen in places along the walls. An ore shoot was encountered on the surface and was prospected by means of a 40-foot shaft. The ore body was found to pitch to the west, so a

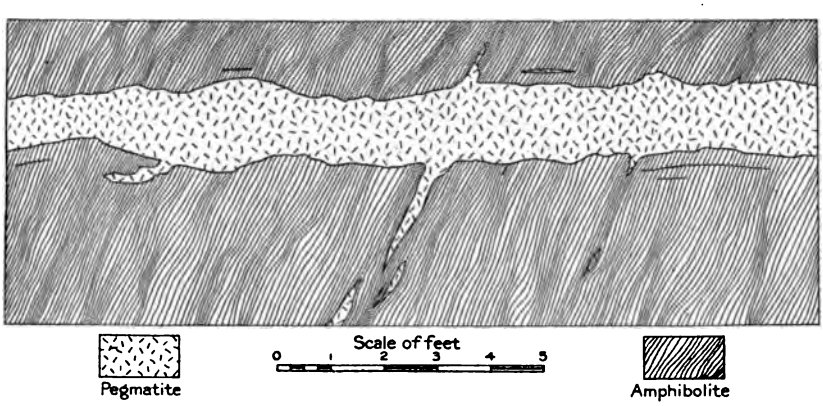


FIG. 5.—Diagrammatic plan showing structure of cross dike of pegmatite, Jones mine, 50-foot level.

drift was run westward from the bottom of the shaft. The main shaft was then begun still farther west. From a point about 50 feet below the surface and perhaps 50 feet east of the main shaft a stope has been made slanting upward and eastward to the surface. The horizontal extent of this stope along the strike of the level varies from 20 to over 50 feet. It is probably somewhat greater in this dimension than the ore body on which it was driven. A sublevel at a depth of 60 feet and the main 100-foot level disclose the dike, with the ore shoot still pitching westward. At the 100-foot level the dike is about 8 feet south of the shaft. A drift westward from the shaft is 45 feet long and is in the ore shoot, whose western limit has probably not yet been reached. On this level the cassiterite is present in smaller grains than usual, and more care is required in following the ore body than where the large dark "crystals" show plainly by candlelight. At the 150-foot level the crosscut to the south finds the dike much broken up. It appears here almost as if what has been cut is not the cross dike, but the interfoliated dike, which has been opened on the surface to the south. There seem to be irregular, lens-like bodies of pegmatite in the schist, and these carry some cassiterite. Some more crosscutting failed to find the regular dike as followed in the workings above, and, since very soft, caving ground was encountered, work was suspended in the bottom. It has been learned since the writer's visit that on the 60-foot level, 50 feet west of the shaft, a northeast dike, doubtless corresponding to the northeast dike known on the surface, was struck. The same dike was cut

again on the 100-foot level, 75 feet west of the shaft, indicating a dip to the northwest, which also corresponds with the interfoliated dike. Here at the 100-foot level it would seem from the descriptions that the two dikes of pegmatite unite. It is not known how much cassiterite was present in the pegmatite encountered in this last work. Operations at the mine were stopped in the summer of 1905. Water was first encountered at 45 feet and has necessitated vigorous pumping since the shaft reached the depth of 65 feet.

The cassiterite occurs in the decomposed kaolin, mixed with mica near the surface, but at greater depth the ore becomes hard and fresh. Some of the fresh ore is comparatively rich, carrying, probably, over 10 per cent of metallic tin. The average of all the pegmatite broken in the mine is said to have been about 0.7 per cent metal. In joints in the fresh amphibolite little scales of yellowish sulphide with radial structure were found. It had been suggested that this might be a tin-bearing sulphide, but it proved to be simply pyrite. It may be that there is some connection between the ore shoot and the intersection or junction of the two pegmatite dikes. No relation was observed, except that the pitch of the two seems to be the same. The junction of the two dikes is apparently west of the ore shoot.

A little placer tin has been obtained in and near the small stream just east of the mine

FAIRES MINE.

The Faires mine is located on the property of Mr. E. C. Faires, about 1 mile southwest of Kings Mountain station. The Carolinas Tin and Development Company, of Gaffney, S. C., holds an option on it. Some work was done during the summer of 1904, but operations were suspended in the autumn. Besides numerous pits, the workings consist of a shaft 40 feet deep and about 200 feet of drifts and crosscuts at its bottom. Hoisting is done by means of a windlass and bucket.

The country rock here is a dark-colored schist, which is probably amphibolite, although decomposition has been so great that a final decision can not be reached. A few hundred feet east of the shaft is a prominent outcrop of quartzite. These rocks strike N. 20° to 30° E., and dip steeply to the northwest. Interfoliated with or cutting at low angles across the schist are several dikes of pegmatite. One of the largest dikes seen in the region occurs not far west of the shaft, where it outcrops conspicuously and can be traced for a considerable distance. Its actual width is not shown, but may be 20 or 30 feet. The step-like outcrop of this dike affords a good illustration of the irregularity of these deposits. Faulting is suggested, but the true explanation is probably found in the presence of several near-by overlapping or en échelon lenses. A short distance east of the shaft are the croppings of a quartz-tourmaline vein.

The pegmatite of the Faires mine is the quartz-mica variety, but in most places contains more feldspar than that of the Jones mine. The large dike above mentioned contains considerable spodumene and small green apatite crystals along with albite, quartz, and muscovite. The smaller dikes contain no spodumene so far as known, but rather more feldspar. Muscovite mica is abundant in nearly all the dikes. A considerable quantity of float tin has been found upon the surface in the vicinity of one of the narrower dikes. A rather perfect double pyramid, weighing about three-fourths of a pound, was found in 1904, and a lump, part of a single individual, without crystal faces, was later found near by. It weighs about 1½ pounds.

A pit where the float was most abundant exposed a dike of pegmatite about 3 feet wide. This dike strikes about N. 30° E. and dips steeply northwestward, being consequently nearly or quite parallel to the foliation of the schist. The dike appears not to be continuous, but to be made up of narrow sections which pitch steeply to the northeast, and are separated by a thin mass of foreign matter, presumably decomposed schist. This division into strips may be due to the faulting which in the underground workings is seen to have taken place. One of these sections exposed by the pit contains a promising proportion of cassiterite, estimated at 10 per cent.

The shaft was started just east of the outcrops of this dike. At its bottom, 40 feet below the surface, a crosscut about 40 feet north-northwest cuts what is probably the same dike.

Along this crosscut are seen several unimportant faults, probably of small throw. As the dike is approached the schist contains many narrow white streaks, a few millimeters wide, which prove to be decomposed dikelets of pegmatite injected parallel to the foliation of the schist. At the crosscut the dike is about 3 feet wide, but broadens along the drift to the northeast, and soon reaches a width of 13 feet. This is known as the west dike. A crosscut 21 feet east from the bottom of the shaft discloses another dike of pegmatite, 3 feet wide, nearly vertical, and striking about N. 5° E. This is called the east dike. A drift which follows it northward for about 55 feet shows that it widens to about 12 feet. At the north end of the drift the dike appears to be pinching out and pitching downward toward the north. At this poin a crosscut from the east to the west dike shows that they are 33 feet apart. A continuation of the northeast drift on the west dike discloses what appears to be the junction of the two dikes, but work was abandoned before this point was settled.

All the pegmatite seen underground is much decomposed. The feldspar and mica apparently both alter to kaolin and silica, causing the dikes to be soft and easily worked. The east dike contains several large masses of this mixture of kaolin and silica which represents feldspar. Remains of the feldspar cleavage are preserved in many places and show that some of the individuals were large, reaching a breadth of several centimeters. These masses were probably segregations of feldspar. They are balanced by lense-like masses of quartz, many of which are more than a foot in length and some of which reach a foot in width. This was apparently a very coarse-grained portion of the dike. The west dike contains many small black particles readily mistaken for cassiterite, but they are soft and can be easily crushed to a dark-brown powder. They are undoubtedly the alteration product of lithiophilite. Purpurite (see p. 38) is associated with the black material in some places.

Cassiterite is present in grains of small size sparingly scattered through portions of the west dike. Larger and more abundant particles of the mineral were found near the northeast end of the drift on the west dike. This richer portion appears to be a shoot pitching not very steeply to the northeast. It is probable that this is the continuation of the shoot exposed on the surface near the shaft. The percentage of cassiterite, even in the shoot, however, was not considered sufficient to warrant further expenditure, so operations were suspended. Water was never encountered in this mine.

To the south and southwest of the shaft several pits have reached pegmatite dikes. Some of these contain such a percentage of tin as to appear worthy of further development.

ROSS MINE.

This mine, located on the property of Capt. S. S. Ross, is about 1½ miles northeast of Gaffney, S. C. It is at present being worked by the owner. Fragments of cassiterite were discovered in the soil early in 1902. Search showed a considerable quantity present on the slope toward a small stream which crosses the property. Considerable of the soil on this slope was sluiced and much of the cassiterite saved. As progress was made southward up the slope tin ore was found in place in compact reddish clay, which changed to white a short distance below the surface. This clay proved to be the decomposed outcrop of a tin-bearing pegmatite dike and attention was then directed to the deposit. A trench showed the course of the dike to be N. 48° E. and its dip 60° to 65° SE. An incline pitching at a low angle was run southward for 135 feet. About 25 feet south of the projection of the bottom of this incline a vertical shaft was sunk on the hanging-wall side of the dike. This shaft cuts the dike at about 100 feet below the surface. At a depth of 75 feet a crosscut west from the shaft reaches the dike in 30 feet, and drifts about 30 feet long have been run along the dike in each direction. Sinking of the shaft is now being continued. The surface developments include a shaft house, two large boilers, and a steam hoist recently installed. A near-by stream has been dammed to furnish a sufficient quantity of water for washing and sluicing the ore.

The country rock of this mine is amphibolite. Decomposition has extended below the present workings, but the true character of the rock can readily be discerned from the freshest rock in the bottom of the shaft. In the bed of the stream to the north also fairly fresh amphibolite is exposed. A number of interfoliated pegmatite dikes are seen at the creek. They are narrow, usually not over a foot in width, and suggest simultaneous injection along planes of greatest weakness. This pegmatite is of the quartz-microcline variety, with only scattered small masses of compact muscovite. Near the bottom of the shaft the pegmatite becomes granitic in appearance.

So far as known the dikes contain no tin where exposed at the creek. It is not even certain that they are the continuation of the dike on which the workings are situated, but such is probably the case. The incline followed a southwestward-pitching ore shoot until the ground became so soft that the workings could not be maintained. Much of this ore was very rich, consisting of soft kaolin and a little quartz surrounding large and small masses of cassiterite. Groups of imperfect crystals and large irregular masses, some of which weighed as much as 100 pounds, were encountered. The drift from the 75-foot level of the shaft is on the extension of this ore shoot. Here the percentage of tin is probably less, but the distribution is more even, rich pockets giving way to disseminated grains from the size of a walnut down. Near the end of the drift to the southwest the shoot passes below the floor of the level. The dike where cut by the shaft, at about 100 feet, consists of a series of apparently disconnected lenses, many of them overlapping, which contain a little cassiterite in small grains. (See fig. 6.) It is the intention to sink the shaft somewhat farther and then to turn a level southward in the hope of picking up the continuation of the ore shoot encountered in the workings above.

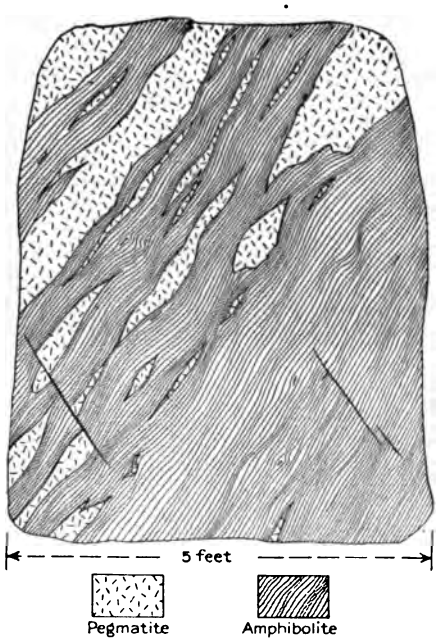


FIG. 6.—Diagram of pegmatite dike of the interfoliated type, Ross mine, 75-foot level, showing extreme irregularity of structure.

It is almost certain that the float tin found in the soil on the slope below the shaft was derived from the upper continuation of this ore shoot above the present surface. Its low angle of pitch would on degradation allow the liberated fragments of cassiterite to cover a considerable horizontal strip with but little lateral transportation. It is doubtful if the quantity of float tin found will be very great. In fact, it seems probable that the greater part has already been removed.

It is difficult to estimate the percentage of tin in the ore because of the variable content of cassiterite in different parts of the dike and the ore shoot. A 100-pound sample across the dike at the ore shoot on the 75-foot level was washed and gave 9 pounds of cassiterite, or about 6.5 per cent metallic tin. This is probably somewhat better than the ore shoot will average. Outside of the ore shoot the quantity of cassiterite in the dike is very small.

Water has been a troublesome factor in the sinking of the shaft and pumping is continued day and night.

One carload of nearly 20 tons of concentrates was shipped to England from the Ross mine in 1903. Another carload, bringing the total shipment to about 75,000 pounds, was sent out in 1904. Several thousand pounds are now on hand ready for shipment. The average content of these concentrates was about 66 per cent metallic tin.

OTHER PORTIONS OF THE BELT.

Considerable prospecting was done in the northern part of the area by Messrs. Carpenter and Rudisill in 1904. This work consisted in the excavation of trenches and shallow pits where the presence of float gave promise of tin in place. The results have been particularly successful, for in nearly every case they have located a dike carrying tin. On the place of William Carpenter, about 11 miles N. 20° E. of the town of Kings Mountain, the relation of the pegmatite to the gneissic granite is well shown. Here, particularly, spodumene is a prominent constituent of the dikes. A shallow pit on a dike just beyond the limit of the granite shows the pegmatite to contain more mica and cassiterite where it cuts the schist, probably amphibolite, than where it cuts the granite. A dike composed almost wholly of quartz and feldspar cuts the granite at this place. Its interesting internal structure is shown in fig. 7.

On property owned by Henry Carpenter, about 1½ miles northeast of Long Shoals, a pit exposes an irregular dike of pegmatite about 6 feet wide, striking N. 25° E. The normal

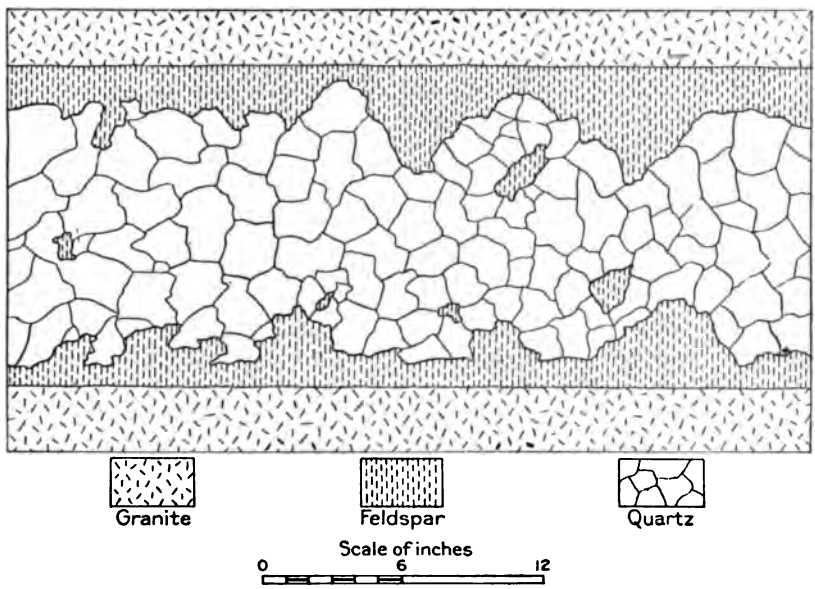


FIG. 7.—Sketch of pegmatite dike, showing internal structure. On property of William Carpenter, Gaston County.

quartz-mica pegmatite with some feldspar occurs on both sides and in the center is a band of quartz-feldspar rock of coarse grain. It is probably an illustration of the aqueo-igneous or veinlike character of pegmatite. The outer portions of this dike carry abundant cassiterite, probably 10 per cent or more. The specimen illustrated in Pl. III, *A*, p. 42, is from this locality.

About a mile farther northeast a number of pits have been put down on property belonging to Ephraim Carpenter. Together with natural exposures by streams, these workings show the existence of what is probably a single continuous dike for nearly half a mile. The general course of the dike is N. 20° E. and the dip is about 80° W. The slight curvature of the line of outcrop is probably no more than is accounted for by the inclination of the dike and the contour of the surface. The dike is 5 to 8 feet wide, and in all the pits shows an amount of tin which ought to make working profitable. Whether this is an indication that the whole dike carries considerable cassiterite or whether the pits, located where the float was richest, struck an ore shoot in each case is impossible to decide without further development. The possibility that the dike contains an ore shoot conforming with the surface is so

slight as hardly to deserve mention. The exposure at one of the streams, which is of course a fairer test than the pits, seems to show the dikes with less cassiterite and hence to indicate the unequal distribution of tin in the dike. In any event, this is one of the most promising prospects in the whole belt.

Numerous other less prominent prospects have been opened in the northern part of the tin region. The Piedmont Tin Mining Company, of Kings Mountain, N. C., has recently been incorporated to develop the promising properties in Lincoln County.

PLACERS.

As may be inferred, the importance of placer deposits in this region is very slight. Some little tin has been won from the soil immediately adjoining and surrounding the tin-bearing dikes at the Ross and the Jones mines, and a small quantity was obtained in the early days in the vicinity of Kings Mountain, but with these exceptions nothing of value has been found and little may be expected from this source.

METHODS OF MINING AND EXTRACTION.

MINING.

Where the rocks have withstood decomposition and are hard, the method of mining is similar to that employed in nearly all kinds of mining where the body to be extracted is narrow, inclined, and more or less tabular. Drilling is, up to the present time, done by hand. Such stoping as has been done has been mostly overhand stoping. Of the several shafts in the district, one is a very flat incline and the others are vertical. Little timbering is needed below the zone of surface decomposition. Near the surface the rocks are usually so decomposed that much timbering and constant attention are required to keep the ground in shape. Where water is plentiful, the walls run in like quicksand. Above the water level drifts can usually be run along the dikes by means of the pick, with only occasional blasting.

Since the present surface is in no way related to the origin of these deposits, a horizontal section of the dike is practically of as great instructive value as a vertical section. In other words, a surface trench 100 feet long reveals about as much as a shaft 100 feet deep. The trench has the advantages of being more expeditious and of much lower cost and of affording greater certainty in following the ore-bearing formation. In general, surface exploration in the way of pits and trenches should first be undertaken. If promising results are thus obtained—to be specific, if an ore shoot is thus exposed—a pit should be sunk upon it so that an idea of its extent, pitch, and richness may be obtained. Then, if the indications warrant, a shaft may be sunk to intercept the ore shoot at a desirable depth, it being borne in mind, however, that the dike and the ore shoot are liable to change direction or to pinch out before such a point is reached. In many respects an inclined shaft following the ore shoot would be the most effective means of development; but the possibility of change in direction of the ore shoot—necessitating either that the shaft be crooked, which is undesirable and uneconomical, or that the ore shoot be left, in which case an incline is less desirable than a vertical shaft—is so great that the risk is probably not justified.

By whatever method the mine is opened, the essential feature of development should be the following of the ore shoots.

TESTS FOR CASSITERITE.

Because of the dark color and metallic luster of the cassiterite from this region, numerous dark heavy minerals found along or near the tin belt have been mistaken for it. Of these the iron ores ilmenite and magnetite are most common. It may therefore be of use to note here one or two simple tests for cassiterite.

Magnetite can, of course, be identified by its attraction to a common magnet. Some ilmenite is also feebly magnetic and can be detected in the same way. If the material is not magnetic, the following test is in many cases of great service. The color of powdered cassiterite ranges from white to brown, but is never black. If a small piece of the mineral in

question is ground to a very fine powder between two clean pieces of steel (the face of a hammer and a shovel will serve), it may generally be safely rejected as not containing tin if the powder is black. If brown or still lighter in color, recourse may be had to the blowpipe test, which is applied as follows: So much of the finely ground material as can be piled on an area one-fourth inch square is added to twice its bulk of powdered charcoal and to three times its bulk of pulverized sodium carbonate, or ordinary washing soda. These three substances are thoroughly mixed and then transferred to a little depression in a stick of charcoal, where they are moistened to a thick paste. The flame of an alcohol lamp is then directed upon them with a blowpipe, care being taken to envelop in the flame as much of the material as possible and at the same time to produce an intense heat. If the operation is properly carried out, the presence of tin will be indicated by the appearance of small globules, which seem darker or less highly heated than the surrounding material. By continued heating numbers of these particles can be made to coalesce into a bead of appreciable size. The formation of such metallic beads or globules is not, however, a proof of tin, but may be due to the presence of any one of a group of metals of which tin is a member. On being removed from the flame the globules often become oxidized on the surface and covered with a white layer which masks their metallic character; but if the melted mass is crushed after cooling the flattened pieces of metal may readily be observed. If a white insoluble residue results when the metallic beads are treated with concentrated nitric acid, it may be considered that tin is present.

EXTRACTION.

The typical tin ore of this region—that is, the unaltered pegmatite containing tin—must be crushed to obtain the tin mineral. Ledoux tried stamping, and erected a 10-stamp mill for his operations. He was met by two difficulties, however. The large foils of mica, being tough and elastic, resisted comminution and gave trouble by clogging up the screens and the mortars, and the heavy impact of the stamps served to crush the brittle cassiterite so fine that much of it could not be saved in the subsequent concentration operations. Since that time stamping has not been attempted.

The equipment of the Jones mill is supposed to be sufficient to handle 100 tons of ordinary material per day. Besides boiler and engine, the machinery consists of a jaw crusher, rolls, elevators, screens, a pair of mechanical two-compartment jigs, and a Bartlett table. The arrangement appears well adapted for economical handling.

Coming from the mine the ore passes through the crusher and goes to a revolving screen, where it is divided into eighth-inch and half-inch sizes. The smaller size goes to the concentrating table and the larger goes to the jigs, while the oversize goes to the rolls and then again through the screen. Considerable trouble has been experienced with the crushing machinery. The mica binds the rock together and makes it tough and springy, so that the crusher is continually being choked. When a stream of water is directed into the crusher the difficulty is slightly lessened, but clogging can be prevented only by frequent prodding with a bar. It is probable that the harder ore now being reached in the lower part of the mine will give less annoyance. The rolls are also subject to the same difficulties, but by the use of an abundance of water they can be kept ahead of the crusher. It is thought by Mr. Seamon, president and general manager of the company, that sluicing of the ore as it comes from the mine will remove a large amount of the mica and thus increase the capacity of the crushing machinery. This can be demonstrated only by experiment. It is believed that the best remedy would be the substitution of a rotary crusher for the jaw crusher now being used. The jigs make a very good product, although it is probable that an appreciable amount is lost by attrition, as the grains removed from the upper compartment are in all cases worn and rounded. It may be found advantageous to take some steps to save the fine material now carried away. Possibly a trap in the broad launder which carries off the tailings would accomplish this end.

To produce a clean concentrate it is necessary to run the material twice over the table. It is intended to reduce the size of the smaller screen and thus give the table a narrower range

of sizes to handle. It is expected that in this way better results will be obtained and that the capacity of the table will be increased, while the jigs are relied on to handle with ease the increased amount of larger size. As the plant is operated at present, it is doubtful if the finest tin is being saved. If the tailings from the Bartlett table were carefully sized and the fines run over a Frue vanner, it is probable that an additional amount could be obtained, but whether the saving thus effected would compensate for the extra cost is not known.

At the Ross mine very little hard ore has been mined, most of the cassiterite thus far taken out being contained in the soft, putty-like kaolin which constitutes a large part of the upper decomposed portion of the dike. Sluicing does not succeed in removing this sticky material from the cassiterite. Some concentration in hand jigs has been done, but the process which seems most simple and effective is washing through a coarse screen and sluicing the material which passes through. Constant turning, with the shovel, of the material on the screen serves to remove the kaolin from the cassiterite. By shoveling over and over the material in the first box or sluice a very good concentrate is produced. This process is the same as that used for the concentration of monazite. Much of the float or placer tin has been recovered in this way, because scarcity of water and the small extent of the deposits have made ground sluicing impracticable.

PRODUCTION.

The only production from the Carolina tin belt of which there is accurate record is that from the Ross mine. This amounted to 38,471 pounds of cassiterite concentrates in 1903 and 35,925 pounds in 1904, a total of 74,396 pounds of concentrates. The actual total content of metallic tin is not known to the writer. The 1903 shipment is said to have run about 70 per cent tin and, according to assays by Ledoux & Co., the 1904 shipment averaged about 66 per cent. On the assumption that the entire output to date has averaged 66 per cent tin, the total amount of metallic tin shipped from the Ross mine has been about 50,000 pounds, or 25 tons. A few thousand pounds of concentrates are now ready for shipment at this mine and nearly a carload has been produced at the Jones mine. From these two sources perhaps at most 20 tons of metal may be obtained. Two carloads of ore sent to England by Ledoux in the early days of activity in tin mining are said to have averaged about 2 per cent metallic tin; the total amount could not have been over 1 ton of metal. If to this is added the amount of cassiterite that has been carried away as curios, specimens, and samples for assay, it is found that the total production of metallic tin from the Carolinas is probably not over 50 short tons. A considerable portion of this amount, probably over half, was derived from lodes, or at least from deposits in place.

ECONOMIC IMPORTANCE OF THE TIN DEPOSITS.

To the mining man and the investor the topic of moment is the prospective economic value of these deposits. Discussions as to geologic occurrence, origin, etc., may enable them to arrive at conclusions which can be reached in no other way, but what they most desire to know is, Will the deposit pay; and if so, how well?

A number of important factors, of which several are more or less interdependent, enter into the consideration of this question. The price of tin, the richness of the ore, the size of the ore bodies and their relation to depth, and the cost of mining, milling, and transportation—all these points demand consideration before final conclusions as to the commercial value of these deposits can be reached.

In a report of this scope, covering a region where so little development has been accomplished and where the production has been so scanty, several of these points can not be discussed satisfactorily. Certain facts which have a bearing on the question have, however, been learned and may be presented.

VALUE OF THE ORE.

Three ore bodies in the district have been prospected by underground workings. Results at the Faires mine were unsatisfactory. It is doubtful if the average content of the whole ore shoot at the Jones mine will reach 5 per cent of concentrates. At the Ross mine the

percentage of cassiterite in the ore shoot may have been somewhat greater, but at the present level of working it is probably under 5 per cent. There is no reason to believe that the average richness of the ore in the deposits, considered collectively, will change with depth. On the other hand, decided fluctuations may take place in individual bodies.

The metallic content of the concentrates can only be inferred from one case. While small selected samples of cassiterite may reach 75 per cent metallic tin, the general run of the concentrates will fall considerably below that figure. Of the second shipment from the Ross mine, 1,860 pounds averaged 72.53 per cent tin, 29,376 pounds averaged 70.31 per cent, and 4,689 pounds averaged 36.50 per cent—in other words, about seven-eighths averaged over 70 per cent and the remainder about 35 per cent, the average metallic content of the whole shipment being about 66 per cent, which is a very good grade for lode tin. It is known that considerable care was exercised in the preparation of these concentrates, so it may be that this figure is rather above the average for the region. The almost entire absence of other heavy minerals in the pegmatite and the purity of the cassiterite itself, however, make it fairly certain that careful concentration will give a clean product of good grade. If the figure for the Ross shipment is the average for the region, it means that every 3 pounds of concentrates contain 2 pounds of metallic tin.

While subject to considerable fluctuations, the price of tin is slowly rising. The average price of metallic tin in the New York market during 1904 was practically 28 cents per pound. A ton of ore containing 1 per cent of concentrates, of which 66 per cent is tin, contains, therefore, about $3.70 worth of tin at the above price. A maximum of the average gross value of the ore from the shoots thus far developed in the Carolina belt is $18.50 per ton. If abundant spodumene is ever found in close association with tin ore of good grade it may add to the total value of the ore, provided it can be separated and saved.

SIZE AND EXTENT OF THE DEPOSITS.

The width of the ore bodies is limited to that of the dikes in which they occur and is in many cases narrower. The average width of those ore shoots which have been explored is probably not over 3 feet and more likely even less. The breadth of the shoots—that is, the dimension in the plane of the dike at a right angle to the pitch, or greatest dimension of the shoot—is less easily determined by a small amount of development. Twenty-five feet is probably a maximum for those already known. The pitch length—the greatest dimension of the shoots—is thus far unknown; but indications are that the concentration of tin in certain parts of the dikes is controlled by factors which are variable and rather easily influenced by surrounding conditions, so that the ore bodies may be expected to be of irregular extent longitudinally.

The fact that the ore bodies represent magmatic segregations from an igneous rock argues, on the other hand, strongly in favor of the probability that there is just as much cassiterite at a depth of 100 or 500 feet as at the present surface. It is not, however, certain, nor even likely, that the majority of ore bodies known at the surface will continue without interruption to great depth. Maintenance of a fixed output as depth is attained will therefore mean increasing cost of exploration, aside from the commonly increasing costs of hoisting, pumping, and other operations with depth.

FUTURE PRODUCTION.

An estimate of the total amount of ore which a mining region will produce must be based on long and careful study and is at best exceedingly uncertain. For a region where so little development has been effected as in the Carolina belt any prediction of this kind would be idle. Certain facts bearing on the probable output of the district may, however, be stated.

The prospecting that has been done during the twenty-five years since the discovery of tin in this region should furnish some idea of the extent and number of the ore deposits. While it is highly probable that some additional deposits will be found, there is no reason

to expect ore bodies of much greater size or richness than those already known. If anything, the probabilities are that the best ore has been already discovered. Furthermore, it is reasonable to suppose that the ore shoots already explored are as good as, or—since mining usually begins at the most promising points—better than those whose existence is known but which have not been developed. In short, it seems justifiable to assume that 5 per cent of the total rock broken along an ore shoot is a generous figure for the average amount of cassiterite to be recovered. Finally, while the ore shoots will usually be found extensive in one dimension, in the other two they will probably be small, and the irregularity of their position and extent will make mining expensive and uncertain.

Glowing predictions that these deposits will soon supply the domestic demand for tin have of course been circulated, and while it is doubtful if they have made an impression on the minds of those acquainted with the region it is well to correct any false idea which such statements may give to others. A little consideration of the meaning of these statements will show their extravagance. The consumption of metallic tin in the United States, which is annually increasing, was 43,120 short tons in 1904. This is equivalent to about 65,000 tons of concentrates containing 66 per cent tin, or a production of nearly 200 tons of concentrates per day. If the ore contains 5 per cent cassiterite, 4,000 tons of ore would have to be raised each day in the Carolina tin belt. When it is remembered that the total production from the region has been about 50 tons of metal the absurdity of such a proposition is apparent.

COSTS OF PRODUCTION.[a]

Cost of mining.—The cost of mining is intimately connected with the position, shape, and size of the ore shoots. As work continues in this region, it is believed that attention will be directed more and more to following these shoots. Their small dimensions in two directions, their usually inclined and variable pitch, and their uncertainty of extent conspire to make their exploration costly.

At the Faires mine the material of the dikes was so decomposed that most of it could be broken down with a pick, and blasting was only occasionally required. Drifting in ground of this description, with a short underground tram and a hoist of 40 feet by windlass, is said to have cost $1 to $1.50 per foot. Sinking would cost more. At the Jones mine, according to reports, work in the hard rock is easier and cheaper than in the decomposed material. At the Ross mine, also, where the rock for the first 80 feet is so decomposed that it is extremely soft, the increased ease of "breaking" it is much more than offset by the care and the timber required to hold the ground. Shaft sinking below the water level under these conditions is exceedingly slow and expensive work. A contract for sinking the two-compartment shaft 50 feet from the 80-foot level, through ground which is rapidly becoming hard, has recently been given for $25 per foot, the company furnishing the machinery. Up to date the tin taken from the deposit in place has cost a little more than twice what it cost to extract the cassiterite from the surface gravels by placer methods.

If these deposits are to be extensively developed, the greater part of the mining will of course be in hard, undecomposed rock, such as is now being broken at the Jones mine. While the water problem may never be a very serious drawback to mining operations in the Carolina tin belt, the topography, geologic structure, and heavy rainfall of the region make it almost certain that the expense of continuous pumping, steadily increasing with depth, must be added to other items to make the total cost of mining.

Owing to the character and extent of the ore bodies, it is to be expected that the cost of exploration, development, and mining will increase with depth at a higher rate than the simple increase in cost of hoisting, pumping, etc.

Oak and pine wood for fuel cost $1.50 to $2 per cord delivered. Material for timbering is also cheap, and the price of lumber is reasonable. Good negro labor can be had for 75 cents to $1.25 per day. A team and wagon, with man, can be hired for $2 to $2.50 per day. Most other expenses are proportionately low, and the long open season is an advantage.

[a] The writer is greatly indebted to Capt. S. S. Ross for most of the figures relating to costs.

Difficulty is experienced, however, in obtaining skilled miners, and inexperienced hands of course make mining much more expensive.

Cost of extraction and smelting.—The cost of extraction of the cassiterite from the surrounding rock, as now practiced at the Jones mine, is probably high. It is to be expected that longer experience will result in a considerable reduction of this cost.

At the present time there are no tin reduction works in operation in this country. A plant erected at Bayonne, N. J., a few years ago was never put into active operation. All the tin produced has accordingly been shipped to England. The cost of smelting per ton of concentrates is $24.75, or about $37 per ton of metal. This agrees closely with the statement that in 1895 the cost and profit of smelting all the tin ore produced in Great Britain was about $35 per ton of metal, or 1¾ cents per pound.[a] The freedom of the Carolina concentrates from such objectionable impurities as sulphur, arsenic, and tungsten ought to reduce somewhat the charges for smelting.

Transportation and miscellaneous costs.—The cost of transportation from the mines to New York is approximately $5 per ton of concentrates, or about 0.38 cent per pound of metal. The freight charges from New York to Haile, Cornwall, England, amount to $2 per ton of concentrates, or about 0.15 cent per pound of metal. To these figures must be added a small amount per pound to cover handling of the ore, sampling and assaying, commissions, etc.

CONCLUSIONS.

The foregoing considerations indicate that the future of the tin industry in the Carolinas is not yet assured. It is believed, however, that in the case of some of the deposits conservative, careful, and systematic mining will be attended with profit. There are a number of prospects of sufficient promise to warrant further development by cautious methods.

The profits made at the Ross mine, which were probably large compared with the expenditure, are not to be taken as a criterion, for a large part of the product of that mine required only washing, and most of the remainder has been derived from soft ground which required no blasting nor crushing.

SUMMARY.

Tin occurs along a narrow belt extending northeastward from the center of Cherokee County, S. C., across Cleveland and Gaston counties to the center of Lincoln County, N. C. This belt represents the distribution of pegmatite dikes and in its position is dependent on the general geologic structure of the region. The pegmatite is closely related genetically to the granite and granitic gneiss which occur along this belt and which are sometimes cut by the dikes of pegmatite. Most of the pegmatite bodies are very irregular in extent. Tin is present as the mineral cassiterite, which occurs only as an original or primary constituent of the pegmatite. This mineral is not evenly distributed through the dikes, but is generally segregated or concentrated along certain lines. The ore bodies or shoots thus formed generally pitch at a considerable angle and are of small cross section, but extend indefinitely along the pitch. They are probably irregular in extent, somewhat after the fashion of the dikes in which they occur. The percentage of cassiterite in the ore shoots may be high in places, but the average value will probably be under 5 per cent. This ore may be reduced to a concentrate of good quality. The cost of production of the metallic tin ought not to be excessive, but will certainly increase with depth. Placer deposits are unimportant. The necessity of shipping the concentrates to England for reduction is a serious handicap and may prohibit operations which would otherwise be successful. The production of the Carolina tin belt will probably always be very small as compared with the amount of tin consumed in the United States.

While the outlook, from the commercial standpoint, is somewhat questionable, it is believed that profit may be realized from a number of the deposits by careful methods of working.

[a] Louis, H., Min. Ind., vol. 5, 1896, p. 573.

GOLD.

INTRODUCTION.

HISTORY AND PRODUCTION.

When the early Spanish explorers came to America they were shown by the Indians rich nuggets and ornaments of gold which came from the Southern Appalachian region. Some of this gold is supposed to have come from the area with which this report deals.[a] The Spaniards mined for gold in Georgia in the seventeenth century. During the eighteenth century very little attention was given to mining anywhere in the Appalachians, although it is supposed by some that gold was found in this section (Brewer mine) before the Revolutionary war.[b] Just at the close of that century placer gold was discovered in Cabarrus County, N. C., and from that time forward prospecting was carried on with considerable vigor. About 1825 vein gold was discovered in Montgomery County, and soon afterwards in Mecklenburg County, N. C.

The first recorded production from the particular area here described was $3,500 in 1829, and came from Lancaster and Chesterfield counties, S. C. In 1830 work was being done in many places and with profit. From that time until the civil war mining was an important industry of the region, and although the rich fields of California lured many from these deposits of lower grade, the indirect result of the California excitement was a stimulation of mining activity in the East. During the war, and for several years after, little mining was done in this area, but in the seventies, eighties, and nineties the condition of the industry improved. At the present time gold mining in this central portion of the Carolinas is not in a very flourishing state. On later pages the endeavor is made to show the causes for the lack of general success in this region.

Unfortunately, no reliable statistics of production from this area are available. The best records to be obtained are those from the United States assay office at Charlotte, N. C., but these, given by States and counties, have been carefully kept for but comparatively few years and hence are of little value. To judge from all available data, it seems probable that the total gold production of this region has been in the neighborhood of $10,000,000. A considerable but unknown proportion of this amount has been derived from placer deposits, but much the larger part has been won by hard-rock mining.

IMPORTANCE.

This area constitutes the southern part of the Carolina belt, one of the three principal divisions established by Becker in his excellent description of the Southern Appalachian gold fields.[c] The mines of this area are among the most important gold producers in the Carolina belt and, in fact, east of the Black Hills. Such mines as the Haile, Brewer, Colossus (formerly Howie), and Kings Mountain have been worked for years and have furnished a large part of the total output of the area.

Placer mining, which could be carried on at little expense, has undoubtedly been exceedingly profitable in many instances and has probably only rarely been conducted at a loss. With lode mining, which is at present by far the more important industry, the case is different. Although numerous rich strikes, with large profits, have been made, lode mining in this region has been on the whole unsuccessful. More has probably been put into the mines, considered collectively, than has ever been taken out. In those mines which are the exception to this rule profit has been realized in general only by constant and diligent care in the exploitation of the ore bodies and in the reduction of expenses.

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[a] Cf. Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 255.
[b] Geology of North Carolina, vol. 2, 1888, p. 234.
[c] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 251-331.

GOLD DEPOSITS.

One great cause of the lack of success which has attended gold mining in this region lies in the fact that instead of one recognized and well-defined type of gold deposit, as is the case in most mining districts, there are various types exhibiting a very wide range in character, and individual mines present more and greater differences than similarities. Such conditions, whether they are appreciated or not, mean expensive mining. Advantage can not be taken of past experience to reduce the cost of exploitation. If methods which have proved successful in one mine are employed in another the chance is that they will be unsuccessful because they are not adapted to the dissimilar conditions of the second mine. Accordingly the owner is loath to apply to a new mine methods which have proved successful elsewhere, and is inclined instead to try new methods which may miss the mark as widely as those already in use.

Because of this absence of a single type of deposit the study of this gold region has been not wholly satisfactory. In most mining districts the geologist sees more and more clearly into the character of the deposits as a whole as his work progresses, nearly every mine adding evidence to aid in the explanation of the type of deposit. In this region, however, the student of the ore deposits is confronted on all sides by new and perplexing features, which, instead of uniting to explain the main problem of the region, result simply in a mass of uncorrelated and distracting facts. Especial and unusual attention has therefore been given to the mine descriptions, since nearly every mine possesses distinctive features and has an importance of its own.

OCCURRENCE AND STRUCTURE.

In spite of the apparently general dissimilarity in character of the Carolina gold deposits, there exist among them all certain close relations which indicate that the differences are the result of extraneous conditions—such as the structure and character of the surrounding rock—and that all the deposits have the same origin.

On the basis of the outward and readily perceived characters these deposits may be divided into two broad types—fissure veins and replacement deposits. These two are joined together by deposits which partake in part of the nature of each. Placer deposits will be considered later.

FISSURE VEINS.

The fissure veins which are essentially quartz veins with more or less pyrite are exceedingly abundant. They are present in nearly all parts of the area, conspicuously appearing because of their resistance to decomposition, wherever the soil is exposed. Many of the larger veins outcrop strongly. The veins occur principally in dense metamorphic rocks and seem to be most common in amphibolite or in the gabbro, closely related to it. They have been formed by the filling of fracture spaces and probably have in many cases pushed their walls apart both by the pressure from below, transmitted by the solutions and by the force of crystallization. In size they range from the merest stringers, a small fraction of an inch in width, to large, solid veins 20 feet or more wide. Most of the veins dip at steep angles. In the majority of cases they conform somewhat closely in strike and dip with the foliation of the inclosing metamorphic rocks, but here and there they cut across the schistosity of the country rock. The interfoliated veins are in general exceedingly irregular. They swell and pinch, turn and jog, split and unite in a most aggravating manner. It has repeatedly happened that a vein of good size and apparent persistency was found suddenly to break up into a mass of small stringers which could not be profitably worked. Conversely it is probable that sinking on groups of these narrow veinlets, which are too poor or too small or too scattered to be profitable, would show that in many instances they unite to form a single large vein or lens which may hold pay ore. (See fig. 13, p. 101.) Cross veins are much less numerous, but from what can be learned they are decidedly more regular and persistent than the conformable veins.

It will at once be noticed that there is a striking similarity in structure between these quartz veins and the pegmatite dikes of the tin belt. (Compare figs. 6, p. 50, and 14, p. 102.) It is believed that this similarity is due to the fact that, although the materials are different, the receptacle is the same. In other words, the form and position of both the quartz veins and the pegmatite dikes are almost wholly dependent on the structure of the surrounding rocks. The explanation of the structure of the quartz veins is therefore the same as that for the pegmatite, which has already been given at some length (pp. 35–37) and need only be summarized here. It is believed that the veins occur along planes which represented places of weakness in the rocks. The interfoliated veins, or those conformable with the sorrounding rocks, are irregular because these places of weakness, the planes of schistosity, were uneven, discontinuous, and irregular. The material from which the veins were deposited, because of its probably greater fluidity than that from which the dikes solidified, sought out even more irregularities, and consequently the veins are less regular than the dikes. In short, it is believed that the bodies of quartz which now exist did not solidify in open spaces of corresponding dimensions which were ready to receive the solutions; but that the solutions, pushing their way along what may in many cases have been the merest fractures, actually forced the walls apart and made the receptacles in which their load was deposited. The force of crystallization [a] may have aided somewhat in this expanding of the openings, but it is believed that the principal factor was the pressure under which the solutions reached this zone of deposition. This pressure, which must have exceeded that resulting from the weight of the overlying rocks, was transmitted from a greater depth, where the weight of the overlying rocks was greater than above. An idea of the structure of these interfoliated veins is given by figs. 12, p. 100, and 14, p. 102. The cross veins, though deposited at the same time as the others, are more regular than the conformable veins, since they occupy later fissures which are definite cracks breaking across the schistosity.

Faulting has not been important. Slight faults with throws of a few inches are sometimes seen in those portions of interfoliated veins which consist of many irregular stringers, but it is not certain in all these cases that the faulting has been later than the formation of the vein, for it is possible that the vein materials simply filled fissures which in places were faulted. In a few cases more important faults are known, but in general there is very little evidence of movement since the period of vein deposition.

As regards internal structure of the veins, it may be said that the quartz is usually dense and massive, but in a few places possesses a granular texture which has led to the miners' term "sugary quartz." In general, the ore minerals occurring in the quartz gangue are irregularly disposed, although in certain deposits there is a more or less decided tendency toward accumulation or concentration at or close to the walls. In a single vein only, the Little Wilson, has any indication of banding in the interior of the vein been seen, and even in this case the narrow streaks of pyrite parallel to the vein walls give little support to the idea of vein banding in the sense of successive deposition or crustification. Druses and comb structure of original formation have not been observed in a single instance in the mines of this region.

REPLACEMENT DEPOSITS.

Large bodies of ore wholly different in outward aspect from the quartz veins occur in several places in the eastern part of the area. While the fissure veins are more numerous, this type of deposit has been more productive. These deposits occur, with only one or two exceptions, in volcanic rocks of the quartz-monzonite-porphyry group and are most common in the fragmental varieties or tuffs. The porous nature and easy alterability of these volcanic rocks, particularly the tuffs, have allowed widespread penetration and replacement by ore-bearing solutions. While minute quartz veinlets are locally present, the great mass of the ore bodies has been formed by replacement of the country rock, chiefly by silica and pyrite; and it seems probable that many of the veinlets themselves are simply cases of extreme replacement and not deposits by filling.

[a] Dunn, E. J., Reports on the Bendigo Gold Fields, Victoria Department of Mines, 1896, p. 25.

These ore bodies are of generous proportions, ranging from 40 or 50 to hundreds of feet in length and from 20 to several hundred feet in width. Owing to insufficient development up to the present time their depth has not yet been definitely ascertained. Some of the ore bodies persist below present workings, which are several hundred feet deep, while others appear to give out at a depth of 100 feet or more. These ore bodies are not tabular and of irregular extent, as might be expected from the form of the rock masses in which replacement has occurred; they are instead large, rudely lenticular or elliptical bodies, whose longer dimensions correspond with the structure of the replaced rock. The reason for this peculiarity of form is not clear. The most plausible explanation seems to be that the deposition of ore was greatly influenced by the presence of cross fissures which contained either ore solutions themselves or different solutions which, mingling with the ore-bearing solutions near the intersection of the two channels, caused a precipitation of the ore. Cross fissures which may have accomplished such a result are known in some places—for instance, at the Haile and Colossus mines. At the Haile they are commonly supposed to have had an effect on the deposition of the ore, but in reality it seems probable that these particular fractures are later than the ore. The question of the form and extent of these ore bodies is therefore not wholly settled.

DEPOSITS OF INTERMEDIATE CHARACTER.

As has already been stated, all the gold deposits give evidence of a common origin. It would therefore be surprising to find among these deposits a sharp division into the two classes just described. As a matter of fact, the division is not sharp. The two types are in reality the end members of a series in which nearly all intermediate gradations are to be found. Few, if indeed any, of the quartz fissure veins fail to show some replacement of their wall rocks; and at the other extreme are the narrow quartz veinlets which represent the easiest channels for the passage of solutions and which gradually fade into the large siliceous replacement bodies. It is as unwise as it would be difficult to divide this series into a large number of types dependent on the amount of replacement along the veins. A few deposits, however, which seem to stand at about the middle of the series, are worthy of brief comment. The ore body of the Ferguson mine, in northwestern York County, is a good representative of this class. At that mine an interfoliated quartz vein penetrates a schistose volcanic tuff. Probably by the metamorphism and induration which accompanied foliation, this rock was rendered more resistant to attack by ore-bearing solutions than in most localities, but some alteration along the walls of the vein has taken place and has resulted in the production of a considerable zone of low-grade ore on each side of the richer quartz vein. The Blackmon, Kings Mountain, and Thompson deposits also appear to resemble in some respects both extreme types.

MINERALOGICAL CHARACTER.

The mineralogy of these gold ores is, on the whole, comparatively simple, but in some instances minerals rare in this association are present in considerable number. Owing to the different conditions under which they were deposited in the fissure veins and in the replacement bodies, the ores from these two sources exhibit certain mineralogical differences. But since the veins in nearly all cases exhibit some metamorphic influence on the adjoining rock, and since the two types of deposits are in a broad way closely related, it would be unwise to attempt to make a fine distinction between the vein minerals and the replacement minerals.

LIST OF MINERALS.

A list of the minerals known in this area which constitute or accompany the gold deposits is here given, together with the name of the mine where they are found and a statement as to whether they are original constituents of the fissure filling or products of replacement in the surrounding rocks. Names printed in italic indicate decomposition products. Those original components of the wall rocks which seem to have been unaffected by the ore-bearing solutions, such as feldspar, amphibole, etc., are not included here.

List of minerals constituting or accompanying the gold deposits. [a]

Name.	Locality.	Occurrence.
GANGUE MINERALS.		
Quartz	All the mines	Fissure filling and replacement.
Calcite	Kings Mountain	Replacement.
	Schlegelmilch	Do.
Sericite	Haile	Do.
	Colossus	Do.
	Brewer	Do.
	Blackmon	Do.
	Brown	Do.
	Schlegelmilch	Do.
	Ferguson	Fissure filling (?) and replacement.
	Kings Mountain	Replacement.
Biotite	Colossus	Do.
	Ferguson	Do.
	Brown	Do.
	Schlegelmilch	Do.
Chlorite	Haile	Do.
	Schlegelmilch	Do.
Apatite	Haile	Do.
	Ferguson	Do.
Rutile	Haile	Do.
Fluorite	Kings Mountain	Replacement (?).
	Schlegelmilch	Fissure filling.
Epidote	Kings Mountain	Probably secondary.
	Schlegelmilch	Replacement (?).
Graphite	Kings Mountain	(b)
Garnet (?)	Jones tin mine [a]	Replacement.
Tourmaline (?)	do	Do.
	Faires tin mine [b]	Fissure filling and replacement.
Pyrophyllite	Brewer	Secondary (?).
ORE MINERALS.		
Gold	All the mines	Fissure filling and replacement.
Pyrite	do	Do.
Galena	Kings Mountain	Fissure filling.
Sphalerite	do	Do.
Pyrrhotite	do	Fissure filling and replacement.
	Asbury	Do.
	Colossus	Replacement.
	Haile	Do.
	Jones tin mine [c]	Do.
Chalcopyrite	Kings Mountain	Fissure filling and replacement.
	Ferguson	Do.
	Mary	Do.
	Big Wilson	Do.
	Colossus	Replacement.
	Jones tin mine [d]	Do.
Covellite	Brewer	Secondary.
Chalcanthite	do	Do.
	Kings Mountain	Do.
Enargite	Brewer	Replacement.

[a] This list is based very largely on a similar list in Doctor Becker's report.
[b] Probably an original constituent of the wall rock.
[c] Vein is auriferous, but of very low grade.
[d] Vein said to be auriferous.

List of minerals constituting or accompanying the gold deposits—Continued.

Name.	Locality.	Occurrence.
ORE MINERALS—continued.		
Arsenopyrite	Kings Mountain	Fissure filling.
	Asbury	Do.
Leucopyrite	....do	Do.
Tetrahedrite	Kings Mountain	(?)
Bismuth	Brewer	(?)
Bismutite	Asbury	Fissure filling.
Bismite	Kings Mountain	Secondary.
	Asbury	Do.
	Brewer	Do.
Tetradymite	Asbury	Fissure filling.
Nagyagite	Kings Mountain	Do.
Altaite	....do	Do.
Molybdenite	Haile	Replacement.
Ilmenite	Ferguson	Fissure filling and replacement (?).
	Other quartz veins[a]	Do.
	Brown (?)	Replacement.
	Schlegelmilch (?)	Do.
Hematite	Quartz veins[a]	Fissure filling.
Magnetite	Jones tin mine[b]	Replacement.
Cassiterite	Brewer	Do.

[a] Deposit not known to be auriferous.
[b] Vein is auriferous, but of very low grade.

DESCRIPTION OF THE GANGUE MINERALS.

Quartz is of course the predominant gangue mineral. In the veins it is generally milky white, but in some cases is so clear that in large masses it appears dark. It is crowded with fluid inclusions, some of which also contain gas and a solid. The mineral shows neither fibrous structure nor crystalline faces. It occurs in irregular interlocking grains, showing a texture similar to that of granite. For this reason the quartz of many of the veins appears granular or "sugary," as if crushed. All the evidence points toward deep seated deposition of the quartz.

As a replacement mineral the quartz exhibits much the same characteristics as in the veins. It is more apt to be bluish and appears to hold fewer fluid inclusions. The grains are usually polygonal, presenting a mosaic appearance. In the wall rocks of veins the quartz appears most commonly as very small lenses, while in the large replacement bodies it composes the greater part of the altered rock.

Sericite is probably next in importance. At the Haile, Colossus, and Ferguson mines it occurs as minute needles and scales, especially along certain planes. It is probably derived from the original feldspar of the rock, and where silicification is extreme is replaced by quartz. At the Brown and Schlegelmilch mines it is scattered through the wall rock. At the Brewer mine it appears to be forming from the unknown mineral already referred to (p. 22). Sericite forms the great mass of the ore body at the Blackmon mine.

Biotite is nearly as abundant as sericite. It is absent at the Haile and Brewer mines, but at the Colossus and Ferguson mines is sparingly present in minute scales of irregular shape. At the other mines where it has been found it occurs as irregular flakes and clusters derived from the uralite of the amphibolite. In all cases the biotite possesses the clear brown color characteristic of contact-metamorphic biotite. Minute shreds of a mineral corresponding to clinochlore are plentiful in specimens from the Haile ore body. The mineral appears to have been the result of vein action, but may possibly have resulted from the decomposition

of biotite. Tiny fragments, a few of which show prismatic outline, are found in the replacement bodies at the Haile and Ferguson mines. This material is probably apatite and affords an interesting connection with the Dahlonega mines, where it occurs in the same habit in the midst of the veins. Rutile is found in minute yellow prisms in ore from the Haile mine. Fluorite in narrow veinlets cuts the quartz at the Schlegelmilch mine and appears to be of later formation than the gold vein. Its mode of occurrence at the Kings Mountain mine is not known to the writer. The association of fluorite with gold—particularly with tellurides such as occur at the Kings Mountain mine—is now well established by the deposits at Cripple Creek, Colo.

The concentrates from the Blackmon mine contain a "black sand" which proves to be a dark garnet. Whether it has any close relation to the gold is not known. Garnet has also been found at the Jones tin mine, where it occurs with biotite, tourmaline, and magnetite in amphibolite close to the quartz vein which carries a small amount of gold. The resemblance in this case to the occurrence of garnet at the Lockhart mine in Dahlonega is marked. It is reported that the tourmaline-bearing quartz veins at the Faires tin mine carry gold.

DESCRIPTION OF THE ORE MINERALS.

Gold occurs in all the deposits, both free in the quartz and inclosed in pyrite. At the Haile mine it also occurs closely associated with molybdenite in heavily pyritized bands, and at the Haile and Colossus mines as thin flakes on joint planes, probably from secondary deposition. Crystalline faces have not been seen. Grains of large size are not now abundant, but the size of nuggets which have been found in the placers indicates that they have been present in portions of the deposits now eroded away.

Pyrite is the most abundant of the ore minerals. It occurs as large and small masses, both well crystallized and of irregular form. It is about equally important in the quartz veins and in the altered wall rock; in some places it constitutes a considerable proportion of each. When crystallized it occurs most commonly as cubes; pyritohedrons are frequently seen, and in many cases minute octahedrons are abundant. Limonite is a common decomposition product of the pyrite, and a yellowish-green powder which results in some cases may be ferric sulphate. In a few places the pyrite on decomposition leaves cavities partly filled with crystalline native sulphur.[a] Mr. Buddell, foreman of the Brown mine, informed the writer that he has broken open large solid masses of unstained quartz and found cubical cavities containing nothing but sulphur. These always came from above the water level. Below the water level many of the cavities contained a yellow liquid (ferric salt?) and a small amount of bright pyrite in fine grains, but no sulphur. The conditions under which these processes of oxidation took place were apparently unusual. At the Colossus mine much of the pyrite is decomposed below water level, presumably by ferric solutions or by sulphuric acid, and not by direct oxidation.

Pyrrhotite is not plentiful. It occurs both in the vein filling and in the replacement bodies, much of it intergrown with pyrite and chalcopyrite. Chalcopyrite is likewise rather uncommon, and occurs in the veins and in the wall rocks. At the Mary mine it is fully as abundant as pyrite. Covellite and chalcanthite are decomposition products of the chalcopyrite, and at the Mary mine red coatings, which are probably cuprite, result where the sulphide is partially decomposed. Enargite, present in small crystals in the ore of the Brewer mine, also decomposes to chalcanthite.

Galena, sphalerite, and arsenopyrite are not unusual associates of gold. The arsenic, antimony, bismuth, and tellurium compounds found with gold at the Asbury and Kings Mountain mines, however, are interesting and uncommon in such relations. Molybdenite in close association with gold is now commonly recognized. Ilmenite occurs in tiny striated laths in the vein quartz of the Ferguson mine. Large flattened crystals of this mineral are rather common in quartz veins, not known to contain gold, in the vicinity of Home, Cherokee County, S. C. Irregular grains of ilmenite found in the wall rock of the Brown and

[a] Cobb, Collier, Sulphur from pyrite in nature's laboratory: Jour. Elisha Mitchell Sci. Soc., vol. 11, pt. 1, pp. 30-31. Tuomey, M., Geology of South Carolina, 1848, pp. 89, 93. Lieber, op. cit., vol. 1, p. 62.

Schlegelmilch mines may in part be due to introduction by the vein solutions. Hematite occurs plentifully in bands in quartz veins which have not been shown to contain gold. It is possible, however, that they are related to the gold veins. Magnetite occurs in the wall rock of a quartz vein at the Jones tin mine and has undoubtedly been formed by the vein solutions. This is another link between the Jones vein and the Dahlonega veins, in which magnetite crystallizes with the quartz. The occurrence of cassiterite at the Brewer mine is noted on page 91.

CONCLUSIONS.

The character and association of many of these minerals are unusual and nearly all indicate that the deposits are of deep-seated origin, having been formed under great pressure and at high temperature.

DISTRIBUTION OF THE GOLD.

GENERAL FEATURES.

The subject of the distribution of the gold in the veins and in the replacement bodies is of the greatest practical importance. It is regretted that information on this point is so meager. In many cases development has not been sufficient to furnish good evidence, and on the other hand deduction from the form, size, and position of stopes is not satisfactory, for they indicate the distribution of only such ore as could be profitably mined under conditions existing at the time they were made.

It may be said, however, that the distribution of gold in the deposits is in general irregular. Some veins or ore bodies seem to be of fairly constant grade, but pockets, pay shoots, and relatively rich lenses within the main deposits are the general rule.

In the veins ore shoots, usually of rather small cross section and of steep pitch, afford the most profitable places for exploration. Where the veins are richest the surrounding altered rock likewise generally contains most gold, but everywhere less than the vein, so far as known. Rich ore is usually accompanied by much pyrite, but there are numerous exceptions to this rule.

In the replacement deposits the bodies of pay ore are large lenticular or ellipsoidal masses, with gradually decreasing values toward the exterior. In a few instances the change from profitable to barren ground is so abrupt that the deposit may be said to have a wall. Within these large bodies the value is not uniform. The best ore generally occurs where most silicification has taken place, and this also in many cases corresponds with the degree of pyritization. At the Haile mine comparatively rich ore is generally found in those places, among others, where molybdenite occurs with abundant pyrite.

The cause of this concentration of gold in certain places or along certain lines has not yet been ascertained. In some cases it is believed that the presence of cross fissures has been influential, but definite proof can not be brought forward. In the case of the replacement deposits at the Haile and Colossus mines it has generally been considered that the diabase dikes which cross the ore bodies have been the controlling factors in ore deposition. This subject is further considered under "Genesis of the deposits" (p. 68), but it may here be stated that careful examination has failed to reveal any genetic connection between the diabase and the gold. Moreover, the fissures through which the diabase dikes were later intruded seem probably to have had no connection with the original deposition of the gold.

SECONDARY ENRICHMENT.

All students of ore deposits recognize that several of the metals are dissolved by surface waters and are reprecipitated in the upper portions of the deposits by the process commonly known as secondary enrichment. It is the general opinion, however, that in the case of gold the solubility of the metal is so slight that this process is of little consequence in enrichment from the commercial standpoint. The importance of secondary enrichment in certain gold

deposits has recently been advocated by Weed,[a] and the consideration of the subject in this place seems to be justified. In the particular case of the Haile mine, moreover, certain facts appear to point rather strongly to such a possibility; and in anticipation of the detailed description of the mine these facts will be presented, so far as they bear on this subject. In view of the erosion which has certainly gone on since the formation of the diabase dikes it is unreasonable to suppose that any secondary enrichment of present importance took place before that event. Moreover, the facts that the diabase is known to be later than the deposition of the original ore, and that most of it is in a fresh condition, make it appear probable at first thought that secondary enrichment has not taken place to any important extent since the intrusion of the dikes. It is true, however, that the diabase is decidedly altered in its upper part, and that it has doubtless been protected from rapid decomposition at greater depth by the layer of clay-like, fairly impervious material produced by decomposition on the top. It is certain that, owing probably to the presence of many joints, which are absent in the diabase, decomposition and oxidation have gone on to a greater depth in the body of the siliceous ore than in the diabase. The absence of these joints may also account for the absence of gold of secondary deposition in the diabase. It should be borne in mind that the idea of secondary enrichment is now applied practically only to deposits of copper. The fairly distinct zones of different mineral composition and strikingly different appearance occurring in enriched copper deposits have unquestionably aided greatly in the recognition of the presence of this phenomenon. But the much simpler mineralogy of gold affords no aid in this respect.

Furthermore, the changes in the vertical distribution of values at the Haile mine are not so extreme or abrupt that they forcibly demand an explanation, as is the case with copper, for example. A little consideration will show also that if secondary enrichment of gold should take place, the results as regards vertical distribution of values might differ markedly from those commonly ascribed to this process. For example, a copper deposit which has experienced secondary enrichment may be divided on the basis of richness into three more or less distinct zones—(1) an upper impoverished zone from which most or all of the copper has been leached; (2) an intermediate rich zone in which the copper originally above has been added to that already existing in the primary deposit; and (3) a relatively low grade zone, of indefinite downward extent, which in value stands intermediate between 1 and 2 and which represents the character of the whole deposit originally. Owing to the extreme ease with which copper minerals are decomposed and the copper taken into solution, an instance is rarely found in which solution and reprecipitation at a lower level have not gone on to a marked extent, unless the gangue and the surrounding walls have been so impervious as to restrict decomposition to the uppermost portion of the deposit. In other words, where secondary enrichment of copper deposits has taken place appreciably it has reached a rather decided degree. With gold, on the other hand, the case is different. The metal is so slightly soluble that currents of oxidizing surface waters may flow around it and reach and decompose minerals far below without appreciably changing the relative position of the gold. But some solution of the gold is undoubtedly taking place and, given sufficient time, during which the process continues, the gold near the surface must ultimately be dissolved and carried to a greater depth, where without any question it will be precipitated, most probably by sulphides or other reducing agents. The difference between the behavior of gold and copper, therefore, is largely one of rate. Since the process in the case of gold requires a very much longer time to accomplish equal results, it is natural to expect that intermediate stages, showing less marked results, will be more commonly encountered than in the case of copper. The recognition that gold is dissolved and redeposited to a slight extent is a recognition of an early stage in this process. This action in the case of gold is so exceedingly slow, however, that it must be a comparatively rare combination of conditions when degradation by erosion will proceed so slowly that concentration of gold from higher levels may become an important determinant of the value of the ore.

[a] Weed, W. H., The enrichment of gold and silver veins: Trans. Am. Inst. Min. Eng., vol. 30, 1900, pp. 423–448.

At the Haile mine the ore values are distributed as follows: The uppermost portion of the deposits, which was worked as placer ground, was rich. Below this surface mantle the values have decreased, so far as known, rather steadily, although pockets of sulphide ore of better than average grade have been encountered, probably most commonly near the boundary of general decomposition. The limit to which economic mining can be carried appears to bear a pretty definite relation to distance from the surface, and that distance is not great and reaches not very far—usually less than 200 feet—below the limit of complete oxidation. Moreover, thin films and scales of pyrite and of free gold have been found in joint cracks which give every appearance of having been formed since the silicification of the rock and the attendant ore deposition. Thin films of free gold are commonly found on molybdenite associated with heavy pyrite bands. Finally, it is certain that the comparatively plentiful gold which was found at the surface of these deposits and which was derived from higher portions of the deposits now eroded away has remained in that place undisturbed for a long period—in fact, ever since the peneplanation of the region, which probably took place as early as Tertiary time. Erosion at these places has been almost at a standstill and the process of secondary enrichment of the deposits, slow as it is, has had time to be effective. The writer does not undertake to say that secondary enrichment has had much to do with the vertical distribution of the gold, but it certainly seems possible that it has. If such a process has gone on, the action has differed from that common in copper deposits, inasmuch as the copper is derived largely from the upper portion of the deposit in situ, while the gold is supposed to have been dissolved mainly from gold which rested upon what was then the surface of the deposits and which had been previously concentrated by mechanical means virtually as placers. (See pp. 74–75.)

Whether or not secondary enrichment has taken place, the present ore bodies of the Haile mine certainly represent original loci of more than usual concentration of the gold in the deposits.

VALUE OF THE ORES.

The value of the ores is of course dependent on the distribution of the gold. Gold is present in much greater quantity than the amount of workable ore would indicate. In the walls of the veins and as horses and outer zones of the large replacement bodies, as well as within many veins, there is much material carrying gold from a trace up to the minimum amount for which mining can be profitably conducted. Of the pay ores the values vary greatly, depending as much on the cost of winning the gold as on the absolute richness of the ore. Some shoots or parts of shoots have been found which carry ore valued at several hundred dollars per ton. The Kings Mountain mine had some very rich ore and ore of high grade has been taken from the Thompson mine. Small, very rich pockets have been found in numerous places. The ore mined from the fissure veins has on the whole been of considerably higher grade than that from the replacement deposits. This is probably due both to the concentration along narrow zones of the gold which the solutions held, rather than dissemination through larger masses, and to the fact that owing to their small size and irregularity in form and richness veins can not be profitably worked when below a certain value; while the large replacement deposits, of more regular outline and certain value, can be made to yield a profit when far below that value per ton.

The ores of this region must on the whole be classed as of rather low grade. While some few mines may always have raised ores of good value, the vein mines have probably produced ore running on the average not better than $8 to $12 and the replacement bodies have averaged from $2 to $12 or $15, the value of the ore in the second case depending rather on the extent to which mining was carried into the outlying leaner portions of the deposits than on the actual amount of gold present.

The values occur both as free gold and in pyrite. It is certain that original, native gold has been deposited from the vein solutions to some extent. At the Blackmon mine, for instance, below the general depth to which surficial alteration has reached, the greater portion of the gold occurs free. At the Haile mine also some of the free gold associated with pyrite and molybdenite was perhaps originally deposited as such. In most cases,

however, it is likely that the gold which has been found in the metallic state, both in the deposits in situ and in the placers, has been liberated from pyrite by oxidation. Whatever the original condition of the gold may have been it is certain that nearly all the gold occurring in the oxidized portion of the deposits has been found in the metallic state, and that as the proportion of sulphides increased the amount of free gold has steadily lessened. To judge from statements of the value of these decomposed outcrops or gossans it appears that they were decidedly richer—in some cases several times richer—than the average grade of sulphide ore below. The solution and carrying away of portions of the vein material, leaving the gold behind in consequently increased proportions by weight, have been responsible for much of this added value which the gossans show. It is probable, also, that gold from overlying portions of the vein has gradually been left behind as the other lighter constituents were eroded away, and has settled down with the degradation of the country. This last kind of concentration is considered more explicitly in connection with the placer deposits (pp. 74–75). In spite of these two explanations of the greater richness of the upper portions than those found below, it is difficult to rid one's mind of the feeling that the upper portions were always richer. For this belief, however, there is little ground. Probably the greater proportion of the output of this area, exclusive of that from placers, has been from sulphides.

The fineness of the gold averages about 0.900, but ranges from 0.700 to nearly 1.000. Silver is the chief ingredient to lower the fineness.

Complaint has often been made that returns from shipments to southern smelters have not agreed with the actual value of the ore. The writer comments on this topic only to say that he heard of no case where careful, systematic sampling was done by the shipper and to point out how necessary it is that such sampling of the ore be done in order to determine its average worth and how nearly impossible it is even with absolute impartiality to choose from a lot of ore one or a few specimens which really represent the whole.

GENESIS OF THE DEPOSITS.

In the preceding sections it has been assumed that these gold ores have resulted from deposition by aqueous solutions. This assumption is so completely sustained by the vast array of facts available both here and in other gold regions that further consideration need not be given to this subject. Granted, then, that the ores have been deposited by solutions, the factors which enter into the consideration of the origin of the ores are the nature of the solutions, their source, and the manner of deposition of their dissolved materials.

It is regretted that a thorough investigation of these deposits could not be made. The reconnaissance character of the examination on which this report is based has not justified the devotion of such detailed and thorough study in the office and laboratory as a complete survey would demand. Moreover, while the deposits deserve careful and complete investigation because of their complexity, for that very reason it is difficult to obtain a fundamental comprehension of their character.

CHARACTER OF THE SOLUTIONS.

Without numerous analyses showing the changes effected by the solutions in wall rocks, much concerning the nature of these solutions is left to assumption. From the materials which constitute the fissure fillings, however, it is certain that silica was the most abundant of the dissolved substances. Metallic sulphides, chiefly pyrite, have also been important. The conversion of feldspar into sericite and of amphibole into biotite indicate that potassium has been taken from the vein solutions by the surrounding rocks and that sodium has been added to the solutions. The production of the micas and of chlorite may mean that the solutions carried aluminum. A small amount of calcium may have been carried by the solutions to form the apatite, or the calcium may have been derived from the replaced rocks. The presence of such oxides as ilmenite and possibly hematite, magnetite, and cassiterite point to conditions rather unusual in the formation of gold deposits. Besides

the commoner sulphides of iron and copper, small amounts of arsenic, antimony, bismuth, and molybdenum sulphides and one or more tellurides were present in some cases. Fluorine and probably boron were contained in some of the solutions. A little phosphoric acid was present and allowed the formation of apatite. There is little or no evidence that carbon dioxide was present.

The nature of these materials deposited from solution, as well as the general effect on the wall rocks, an effect resembling that produced by contact metamorphism, points to the conclusion that the ore-bearing solutions were concentrated and at high temperature. The almost entire absence of banding in the veins and the widespread effect of the solutions in the replacement deposits, as shown by the large size of these deposits, may be taken as additional evidences of concentration of the solutions.

SOURCE OF THE MATERIALS.

The character of the minerals deposited, the metasomatic action on the surrounding rocks, the structure of the veins, and the amount of erosion which the region has undoubtedly suffered since the deposits were formed are grounds for the belief that the ore bodies now exposed were formed far below the surface of that time. The character of the solutions, moreover, points not only to deposition at high temperatures but to their derivation far below. The source of these materials was therefore at greater depth than their place of deposition, and the solutions were at even higher temperature at the beginning of their upward journey than when the dissolved materials were precipitated.

Such extremes of depth and temperature suggest at once a magmatic origin of the solutions. Such an origin can not be established with absolute certainty, but a number of facts appear to favor it. Granite is known in the vicinity of many of the mines. How large a body of granite exists below the present surface it is of course impossible to say, but it is probable that the areas exposed are small parts of a much larger mass. The absence of granite outcrops immediately around the mines does not, therefore, preclude the possibility that the veins or solution channels reach granite somewhere below.

The intimate association of granitic or aplitic dikes with the quartz-tourmaline veins of the tin belt and the close resemblance in many respects of these veins to the gold-quartz veins make the relation of the gold deposits to the granite rather probable. This probability was so apparent and the resemblance of some of these tourmaline veins to the auriferous veins of the Lockhart mine in Dahlonega was so marked that it was decided to have specimens of some of the tourmaline veins assayed for gold. Two samples were selected—one from the quartz vein, which occurs close to the aplitic dike at the Jones mine, the other from a quartz-tourmaline vein, reported to be auriferous, near the pegmatite dikes at the Faires mine. It should be stated here that the specimens tested were not collected in the field with the assay in view; otherwise more conclusive results might have been obtained. Very careful assays were made by Messrs. Ledoux & Co., of New York.[a] The results were as follows:

No. 1. Quartz vein, with tourmaline, Faires mine, 0.0003 ounce per ton.
No. 2. Quartz vein, with pyrite, Jones mine, 0.0111 ounce per ton.

No. 1, from the Faires mine, is of course valueless, and the assay doubtless means that no gold was present in the sample submitted. The writer is inclined to believe, however,

[a] The method used in these determinations is here quoted from a letter from Ledoux & Co. to the Director of the Survey:

"To avoid possible contamination or salting the samples were ground to flour fineness in porcelain pebble mills, which had been cleaned by grinding clean quartz in them for several hours, followed by a charge of common salt.

"The pulp from the pebble mills was divided into lots of 2 assay tons, each of which were run separately by crucible assay. In the case of 'S. C. No. 7' [No. 1] eight charges, making 16 assay tons, were made, and in the case of 'S. C. No. 42' [No. 2] nine charges, making 18 assay tons, were made. In each case all of the sample was used.

"The buttons from the crucible assays were united and scorified to a size suitable for cupellation. An excess of silver (20 mg.) was added to the scorifiers for the purpose of preventing cupel losses of the gold. . . . The silver beads obtained were parted and washed in the usual way, and the gold weighed on a balance sensitive to one four-hundredth mg.

"Charges of flux equal in weight to those used on the ores were run through contemporaneously with them and treated in exactly the same way, but no visible amount of gold was obtained in the blanks."

that a specimen selected for that purpose would have proved more satisfactory. No. 2 indicates that gold is certainly present in the quartz vein at the Jones mine. While 23 cents per ton is of course very little, it must be remembered that it is not a negligible amount, since 50 to 60 cent ore has been mined in California and some of the ore now being milled at the Brewer mine is said to be not much above 50 cents.

The fact, therefore, that some of these tourmaline-quartz veins, which are almost undoubtedly of magmatic origin—derived from the granite magma—carry gold is a strong argument in favor of their being an intermediate stage in one complete cycle, and fairly well establishes the relation of the gold deposits of the region to the granite. It may be noted here that the gold deposits of Dahlonega are believed by Mr. Lindgren to have a genetic relation to a granite similar to, if not actually the same as, that occurring in this region.

In conclusion, it may be said that while the source of the solutions can not be definitely proved, the weight of evidence favors the view that the gold deposits represent the final products of the granite magma, the concentration of certain elements from an immense body of rock. The full geologic sequence is therefore doubtless as follows:

1. Intrusion of granite.
2. Intrusion of granitic or aplitic dikes causing the development of biotite and amphibole in their wall rocks.
3. Intrusion of pegmatite dikes, some of which carry cassiterite, impregnate the surrounding rocks with tourmaline, and cause the development of biotite and other metamorphic minerals in their walls.
4. Formation of quartz veins carrying tourmaline, ilmenite, sulphides, etc., and, in some cases, gold, causing in their wall rocks the development of tourmaline, magnetite, biotite, garnet, ilmenite, and sulphides.
5. Formation of quartz veins (and replacement deposits) carrying ilmenite, sulphides, and gold, and causing in the surrounding rocks the development of fluorite, biotite, sericite, ilmenite, sulphides, and gold.

It is necessary to consider more fully at this point a subject to which reference has already been made—namely, the relation of some of the large replacement bodies to the diabase dikes which cut them. In former descriptions of the Haile mine it has repeatedly been stated that the ore bodies were caused by the dikes of diabase, which occur in their midst. The same has been said of the Colossus mine, where similar conditions exist, and as an explanation of the formation of ore at the Brewer mine it has been stated that a diabase dike occurs close by. Particular attention was given to testing this hypothesis, especially at the Haile mine. The statements that the ores at this mine are richer in the vicinity of the dikes are frequent and fairly consistent. It is often stated, on the other hand, that the richest ore is not immediately surrounding the dike, but at a distance of several feet. This richness in the neighborhood of the dikes may be accounted for in four ways:

1. The ore may be the result of the intrusion of diabase, as commonly stated.
2. The deposition of the ores from the vein solutions may have been influenced by solutions from a different source that were present in the fissure later occupied by the dike.
3. Secondary enrichment, which was possibly a factor in the present distribution of the gold, may have been especially effective along the fissures at the sides of the dikes.
4. The unequal distribution of the gold may be in no way related to the dike or to the fissure occupied by it.

These possibilities will be considered in order.

1. If the diabase and the ore are genetically related, they came from the same source and through the same channel.

Development work outside the main ore lenses indicates the presence of no more gold or other materials of the ore at the contact of or near the dike than is found away from it. Both in and outside of the ore bodies the only visible effect which the diabase has had on the surrounding rock is a slight induration extending an inch or two from the dike. Where

decomposition through weathering has taken place along the sides of the dike, a zone of alteration is present and is characterized by the softness of the rock, formation of limonite, and development along joints of minute crystals of gypsum. But this has nothing to do with the dike itself. Moreover, the diabase, with the exception of atmospheric decomposition, is perfectly unaltered where it cuts either the ore bodies or the barren rock. Little or no pyrite is present and no evidence of the action of vein solutions is seen. Such conditions would be almost impossible if the diabase were as old or older than the ore. The distribution of the ore bodies with respect to the dikes argues strongly against this hypothesis. Instead of being parallel to the dikes, as would be expected according to this supposition, they occur only at intervals, separated by lean or barren spaces, and have their long directions transverse to the dikes. The ore body at the Colossus mine is said to extend several hundred feet away from the dike on each side. In the Haile mine some of the best ore has been found at a considerable distance from the dikes. The writer is not aware that the ore is richer near the dikes at the Colossus mine; and at the Brewer, mining has not been conducted along or on the dike, if indeed a dike is present. Finally, the ore body at the Colossus mine is said to be faulted along an unsheared diabase dike, showing that the dike is later than the ore. There is also evidence of a fault in the vein along a diabase dike at the Wallis mine in York County, S. C.

At the Haile mine, furthermore, several narrow, decomposed diabase dikes, called by the miners "clay" dikes, are cut by and are consequently older than the large dikes which are commonly considered to have brought in the ore. It would be natural to expect, therefore, that these small older dikes would be converted into ore like the surrounding tuffs, or at least would show some effect of the ore-bearing solutions. But all the evidence obtainable indicates that these older dikes are themselves younger than the ore. Neither where most decomposed nor in the fresh cores, which can be found here and there, is more than a trace of pyrite present, and these traces are not ore—so far as the writer is aware they carry no gold whatever, even where in the midst of a large ore body.

It is apparent, therefore, that all these diabase dikes are younger than the ore, and had no connection with its formation.

2. Several facts argue against the theory that increased deposition of ore was caused by different solutions contained in the fissures now occupied by the dikes, at their intersection with the ore-bearing channels. Outside the ore bodies there is no evidence of the action of solutions along these dike fissures except the slight induration caused by the dikes and the later decomposition which has gone on in some places. The distribution of the rich portions, as noted in (1), is likewise against this supposition. Moreover, if these cross fissures existed when the ore was formed, the ore would naturally extend along them for at least a short distance beyond the general limits of the ore body, but such is not the case, and the fissures now occupied by the dikes are probably of later formation than the ore. Finally, it is an unwarranted assumption that a fracture existing in pre-Cambrian time, the probable date of vein formation, should still be a prominent plane of weakness when the diabase was intruded, probably in Jura-Triassic time.

3. Even if it is granted that there has been secondary enrichment of the deposits, the relation of the ores to the dike fissures is not decidedly marked and the tenor of the ore remains fairly constant for such distances away from these fissures that it seems improbable that they have exerted much more influence in the enrichment of the ore than have other fractures, crevices, and joints.

If it is true, as sometimes stated, that the ore within a few feet of the dikes is of lower grade than that a little farther away, it is possible that leaching of the gold has taken place along the decomposed zones bordering the dikes and that secondary deposition has gone on below. There is no satisfactory evidence of such phenomena, however.

4. The only alternative remaining is that the ore deposition, preceding the formation of the dike fissures, is in no way related to them. The only places where increased richness in the vicinity of the dikes has been noted is where the dikes cut across about the middle of the ore body. But that is just the place where a replacement deposit is apt to be

richest. The fact that in some cases the ore bodies pitch away from and leave the dikes ought to be good proof that the ore deposition was independent of the dikes and dike fissures.

DEPOSITION OF THE ORES.

In the consideration of this subject also the lack of analyses prevents the drawing of accurate and valuable conclusions. It has been shown that the ore-bearing solutions were probably under greater pressure and at higher temperature near their source than at the place of deposition. A ready explanation of the cause of deposition would be that the decrease in pressure and temperature lowered the solubility of the materials carried in solution and thus resulted in their precipitation. It has been pointed out by Mr. Lindgren,[a] however, that in general increasing temperature and pressure do not increase the solubility of ore minerals beyond certain maxima, and that consequently the effect of decreasing pressure and temperature on the deposition of ores has probably been overestimated. It is certain, on the other hand, that these changing conditions must have had some effect on the deposition of the ores, but there is no evidence by which to measure it.

It is believed by the writer that the deposition of the ores was brought about mainly by a change in composition of the relatively concentrated solutions. This change in composition would disturb the nice equilibrium which had been attained, and cause a decrease in solubility and consequent precipitation of some or all of the constituents. Such a change in composition of the solutions might be brought about in any or all of three ways: First, change in conditions of temperature and pressure. This would have some effect, probably not very great. Second, mingling with solutions from another source, such as atmospheric waters along cross fissures or channels. The intersection of such channels with the ore-bearing fissures may have fixed the location of extraordinary deposition, the pay shoots. While the vein solutions were doubtless under greater pressure than that which would be due to hydrostatic head, it is conceivable that solutions from the surface, which would be under hydrostatic head only, might mingle with them in spite of this difference of pressure, through the agencies of friction, capillarity, and diffusion. Third, the mutual chemical reaction of the solutions and the surrounding rocks. The subtraction of silica, potash, and possibly alumina from the solutions and the addition to them of soda and lime, which have taken place in nearly or quite all cases, would exert a very pronounced influence on the solubility of the remaining substances and cause their precipitation. It is believed that this third factor was the most important in the deposition of the ores.

The gold and sulphides in the veins have probably been precipitated in part mechanically with the quartz and in part chemically. These heavy metals have also been carried with the silica and lighter metallic elements into the wall rocks and there deposited, though less abundantly than in the fissures.

It has been stated (p. 61) that the fissure veins and the replacement deposits probably had the same origin. The occurrence of similar minerals in the two types of deposits and the presence of deposits of intermediate character sustain the conclusion that the nature of the solutions and the source of the materials were the same in each case.

In the mode of deposition of these materials from the solutions must lie an explanation of the differences which exist between the two classes. Briefly stated, these differences are as follows: The fissure veins are narrow and relatively rich; they effect a very marked change in their wall rocks for a short distance away from them; they occur in dense, usually basic rocks, already rendered resistant through profound regional metamorphism. The replacement deposits are large and irregular; they consist of altered country rock, and they occur in porous volcanic rocks of acidic character, easily susceptible to alteration.

The ore-bearing solutions, ascending at a high degree of concentration and temperature, would, on confinement to a narrow fissure, be able to exert intense action on the immediately adjoining, not easily pervious wall rock. The same solutions, reaching a body of porous, easily alterable material, would immediately disseminate through it, distributing

[a] Gold-quartz veins of Nevada City and Grass Valley districts, California: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, pp. 177–178, 183.

their heat and chemical energy through a large mass of rock. Such a dissipation of energy in the replacement bodies would account for the lower intensity of alteration in them than in the wall rocks of the fissure veins. The difference in chemical composition of the wall rocks in the two cases would explain the mineralogical differences in the two types of deposits.

This hypothesis assumes that the rock invaded by the solutions was at a lower temperature than the solutions. The solutions from lower depths and probably from the vicinity of recent intrusions can hardly have failed to transfer heat to the places of ore deposition more rapidly than could be accomplished by conduction from the same source through the rocks. The possibility that secondary enrichment has modified the original deposition of the ores has already been referred to (pp. 65–66).

CONCLUSIONS.

The gold deposits of this area are of two types—fissure veins and replacement deposits—with transitional members between these two extremes of the series. Concentrated solutions containing gold, silica, potash, sulphides, and oxides of iron and titanium ascended from great depth at high pressure and temperature. In the denser rocks they forced their way along crevices, forming veins, at the same time exerting so marked metasomatic action on the walls of these fissures that the result bears resemblance in many ways to the effect of contact metamorphism. Gold, pyrite, ilmenite, and other materials were deposited in the veins and in the wall rocks. In the more porous rocks the solutions permeated large masses and replaced the original rock fragments by quartz, sericite, gold, pyrite, apatite, etc. The mineralogical differences in these two types of deposits are due to the differences in chemical composition of the rocks invaded by the solutions and to the different degrees of concentration of action of the solutions. The source of the ore materials was at great depth below the surface of that time, but of unknown distance below what is the present surface. It seems certain that the vein solutions are genetically connected with the granite intrusions, representing the final product of the granite magma and bearing close relation to the tourmaline-quartz veins and the pegmatite dikes carrying tin, which were formed immediately preceding the formation of the gold veins. The deposition of these materials was probably due partly to decrease of pressure and temperature attained by the passage to a higher level, but was doubtless caused mainly by a disturbance of the nice equilibrium of solubility and concentration by the accession of substances dissolved from the wall rock.

These deposits differ markedly from the common western type of gold-quartz veins. From the amount of erosion which has taken place since their formation, as well as from the character of the deposits themselves, it is certain that they represent the deeply buried stumps of quartz veins which originally extended much higher. Whether or not the upper portions of these veins, now eroded away, more closely resembled the typical gold-quartz vein it is impossible to say.

The numerous nuggets of large size found in the placer deposits may be an indication that the upper eroded portions of the veins were richer than those portions now known. The ore has become too lean to be profitable or has pinched out at depths not exceeding 400 or 500 feet in so many cases that this may be considered the general occurrence.

It may therefore be that an uneven zone not many hundred feet below the present surface represents the lower limit of the gold—namely, the place of beginning of deposition. It is extremely doubtful, however, if the difference of conditions in this distance of a few hundred feet—a very slight distance compared with the original vertical extent of the deposits—could have caused so great a result. It is possible instead that ore exists far below the present surface, but that the individual bodies of pay ore known at present give out at comparatively small depths, to be succeeded farther down by other and still other ore bodies. Thus, while the ore may persist with depth, it is by no means certain that mining operations will succeed in finding the lower ore bodies. If secondary enrichment has had any marked influence on the value of the ore, the prospects for large bodies of workable ore occurring at depth are not bright

AGE OF THE DEPOSITS.

Concerning the geologic age of the gold deposits little direct evidence is obtainable. The deposits were formed after the greatest metamorphic movements had ceased, but the crushing and slight faulting which some of them have experienced indicate that they did not escape all movement. It seems probable that movements which did affect them were the last agents of dynamic metamorphism. This supposition is supported by the one that the gold deposits closely followed the granite intrusions. The ore bodies are cut by the diabase dikes, which are probably of Jura-Triassic age. All available evidence points to pre-Cambrian as the probable age of the deposits.

PLACERS.

It is said that the gravels of nearly all the streams of this area yield "colors" of gold when panned. Where the gold is sufficiently abundant these placer or "branch" deposits have been worked, often with profit. In the early days discrimination was not always made between the true placers and the loose, decomposed outcrops of deposits in place.

While placers have been of importance in this portion of the South, most of the placer mining was done in the early days of the gold excitement, and information is not easily obtained at present. The location of only a few of these deposits is now known.

A deposit from which much gold was taken was called the Martin or Enterprise mine, and is situated about 1 mile southwest of Smyrna station, in York County. The placer is said to have been discovered about 1836, and most work was done before the war along a shallow stream which has been "washed" several times. It is said that the workable gravels had an areal extent of 4 acres.[a] Much gold has also been picked up from the nearby fields after rains. It is reported that a nugget worth $44 and numerous others of less value have been found at this mine, and Lieber states that a piece of quartz containing 4,000 pennyweights of gold was found in the gravels.[b] One man took out $40,000 before the war, according to report. It is stated that a gold-bearing vein occurs close to the creek, and pits have been sunk there, but at the time of the writer's visit no indication of a vein was seen. The last work here was done four or five years ago.

Much work was done in the early days at the Brewer mine in what is known as the Tan-yard pit. This was probably the first placer in the State. It is several hundred yards from the hard-rock workings and occupies a very slight depression below the surface of the peneplain, although a short distance away is a rather deep stream valley.[c]

A little work has recently been done a few miles south of Gaffney, S. C., but has not proved successful. Washing is being done on a small scale in a stream near the West mine. The Belk placer, in Lancaster County, east of Lancaster, the Austin placer near Gaffney, and numerous others were being or had been operated at the time Lieber wrote his reports.[d] Small nuggets have been picked up in the fields in many places, often not near any stream or depression nor in the neighborhood of any known deposit in place.

Two features concerning these placer deposits are worthy of note. The first point is the richness of some of the placers when compared with the usual low grade of the hard-rock deposits. In the second place, deposits, some of them rich, of waterworn gold have not uncommonly been found on elevations and divides away from and above present streams or valleys. This fact was observed as early as 1825 by Professor Olmsted,[e] and it is stated by Lieber that these placer deposits commonly occur on the foot-wall side of the near-by vein or hard-rock deposit.[f]

From these facts two conclusions may be drawn—namely, that the present streams have not been the only factor in the concentration of the gold and that much of the gold has been

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[a] Lieber, op. cit., vol. 1, pp. 75–76; vol. 3, pp. 154, 157.
[b] Op. cit., vol. 1, p. 76.
[c] Cf. Lieber, op. cit., vol. 1, pp. 66–67; vol. 3, p. 157.
[d] Op. cit., vol. 1, pp. 76–77; vol. 2, p. 71.
[e] Am. Jour. Sci., 1st ser., vol. 9, 1825, p. 13.
[f] Op. cit., vol. 1, pp. 157–158.

derived from portions of the veins which were once above the present peneplain level (cf. pp. 12–14) and owes part of its concentration to the old streams which accomplished this planation and are now extinct.

In the discussion of the tin placers it was shown that as the surface of the land was gradually lowered by erosion from pre-Cambrian time to the present the heavy resistant minerals were left behind in such depressions as existed, constituting placer deposits. In the case of cassiterite the friability and solubility of the mineral probably allowed most of this accumulation to be carried away when the rate of degradation became very slow. With gold, on the other hand, its toughness, high specific gravity, and resistance to ordinary solvents allowed such amounts of it as had accumulated to remain. In other words, it seems probable that the placer deposits of this region represent concentration of the vein gold from that vast amount of material which has been eroded away since the veins were formed. The finer particles of gold have probably been carried away mechanically and the coarser grains have doubtless been slightly reduced in size by solution, but a large proportion of the content of the hard-rock deposits between the present and the original surfaces is probably now in the placers. This hypothesis would account for the comparative richness of the placers. The redistribution of streams on the revival of drainage after base-leveling explains the independence of present topography which some of the deposits show.

MINING DEVELOPMENTS.

GENERAL STATEMENT.

EXTENT.

Mining has been going on in this region for seventy-five years, and much work has been done. The effort has been expended at many places, however, and there are no extensive mines in the area. A few mines, nevertheless, by a comparatively small amount of development work, have opened up large ore bodies on which extensive open cuts or stopes have been made. The deepest working in the area is at the Haile mine, where a winze extends 130 feet below the bottom or 350-foot level. The Kings Mountain mine is about 350 feet deep and the Colossus about 320 feet. Other mines having considerable workings are the Brewer and Blackmon, and it is said that there has been a relatively large amount of underground development at the West mine.

METHODS OF MINING.

The methods employed to obtain the ore from the deposits are varied in character. The placers were worked by panning, rocking, and sluicing; so far as known hydraulicking has been practised in this area only at the old Tanyard placer at the Brewer mine. The same methods were applied to the decomposed upper portions of many of the deposits in place, sometimes in conjunction with crushing. When solid rock was encountered, development was carried on by means of shafts and levels. In general, the flat character of the country does not make tunnels advantageous. One has been driven at the Brewer mine, however. Vertical shafts are much more common than inclines, although numerous inclines were sunk on the veins or on the ore shoots in the early days. The interval between levels is usually small, but ranges from 30 to over 100 feet.

In the large replacement bodies the best ore was mined by stopes from underground workings. In the best practice levels turned from the shaft were run along the hanging wall of the ore body and at intervals raises were driven to the level above. The ore thus blocked out was broken by overhead stoping, pillars and level floors and roofs being left to hold the workings intact. When the levels were no longer needed, these pillars could be taken out. This method of mining was successfully employed for many years at the Haile mine by the manager, Capt. Adolph Thies. An ingenious means of driving the raises economically was put in practice at that mine and well deserves description. The steep dip of the ore body made it necessary either to drive steep raises or to drive them partly in barren ground. The latter was not feasible, and the former necessitated timbering for the

support of workmen and drills. It was found that in a raise driven at an angle of about 45° the broken rock would just serve as a foundation from which to work. The raises were therefore started from the levels at the hanging-wall side of the ore body and driven upward at 45° diagonally across the deposit. When the foot wall was reached the raise was turned to the right or left, first along the foot wall, then toward the hanging wall, and finally back again toward the foot wall, always being pointed upward at 45°. A spiral raise was thus driven, all in ore and without the use of timber. The cost of increased length of the raise was more than balanced by the saving in timber.

As the better grades of ore in these deposits were exhausted it became apparent that the shaft-level method of working when applied to the larger surrounding bodies of lower-grade ore would necessitate timbering and become too expensive. Since the workings were not very deep, it was found possible to extract the low-grade ore and take out the higher-grade pillars by means of open cuts. This method is now being used at the Haile and Brewer mines, has been used at the Blackmon mine, and it was announced as the intention of the management to put it in operation at the Colossus mine. No timber is required and the rock can be broken by quarrying methods. The result is that although in some cases considerable barren ground has to be broken, especially from the hanging wall, the cost of mining is greatly reduced. At the Haile the ore is hoisted in skips running on inclined tracks laid on the foot wall. At the Brewer a tunnel connects with the bottom of the pit or open cut and the ore is trammed out through it.

The depth to which open-cut mining can be carried with profit will of course depend on the strength and firmness of the walls, the size of the deposit, and whether it stands vertically or dips beneath the surrounding rock.

METHODS OF EXTRACTION.

The methods of extraction of placer gold have already been mentioned under the head "Methods of Mining." The same applies to the gossans of many veins. Hard rock containing free gold, either original or derived from oxidation of sulphides, is generally stamped and amalgamated. Sulphide ores containing also native gold are in most cases stamped, amalgamated, and concentrated, the concentrates being either shipped for smelting or else chlorinated or cyanided on the spot. At the Ferguson mine amalgamation has been discarded and the stamp-mill pulp is concentrated, the headings saved for roasting, and the tailings cyanided. At the Colossus mine a 500-ton mill nearly completed will crush the ore in rolls to 30 mesh and then cyanide direct. Both weak and strong solutions will probably be used. At the Haile mine stamping of the ores is followed by amalgamation of the free gold, while the concentrates are treated by the barrel-chlorination process, which was invented by Captain Thies, the former manager of the mine, and which is now in successful operation in the West, particularly on the ores of Cripple Creek, and also in Australia. The same methods have been employed at the Brewer mine.

Throughout the area much difficulty has been experienced in extracting the gold from sulphide ores by amalgamation, even when a considerable proportion of the values is free gold. From what can be learned of these operations, it seems probable that much of this lack of success may be attributed to lack of experience in the stamp milling of ores. Just the right combination of weight and drop of stamp, height of discharge, size of screen, and amount of water seems in many cases to have been missed, and in consequence the tailings were rich.

It is doubtful if the ores of this area can be successfully treated without concentration, roasting, and subsequent lixiviation of the sulphides.

COSTS OF PRODUCTION.

Little satisfactory information could be obtained on the subject of costs, as the mining companies are rather reticent about it. Labor and fuel are low in price and all kinds of operations can be carried on during almost the whole year. Pumping has to be done in nearly all the mines, but the quantity of water is not excessive.

At the Brewer mine, where loose, sandy ore is milled down into cars, trammed to the mill, run through stamps to insure uniform fineness, and then amalgamated, it is said that the total cost is under 60 cents per ton. These operations, however, can be carried on only for a short time before ore of this character will be exhausted, so the above figures have little significance. At the Blackmon mine underground stoping of a large ore body is going on, the ore being stamped and amalgamated. It is said that $2 ore gives a fair profit.

Accurate account is kept of all expenses at the Haile mine. Here large ore bodies, well developed, are mined by open cuts, the ore is stamped, amalgamated, and concentrated, and the concentrates are roasted and chlorinated. Considerable development work, particularly with diamond and churn drills, is being done. For the last two years the total cost of these operations has been under $1.60 per ton of ore mined. This, it will be admitted, is exceedingly low.

HAILE MINE.

The Haile (formerly called Hale[a]) mine is situated on Lynches Creek, 3½ miles northeast of Kershaw, in the southern part of Lancaster County, S. C. It is the property of the Haile Gold Mining Company, of New York City.

HISTORY AND PRODUCTION.

This mine has been worked more or less continuously since about 1830 and during all that time has been one of the most important mines of the region. In early days leases were given on sections 50 feet square, and open cuts were made on these claims by slave labor. This was of course disastrous to systematic, economic mining. The upper, oxidized portions of the ore bodies were rich and some of them yielded lumps of gold worth from $300 to $500.[b] Except during war time, open cutting was carried on until about 1880, when actual underground mining was begun and continued up to about four years ago. A return to the open-cut system has been made, on a much larger scale than formerly. This mine, said to be the only steady dividend-paying gold mine in the Southern Appalachians, owes its success in recent years very largely to the intelligence and persistent efforts of Capt. Adolph Thies, who for nearly twenty years was its manager. Mr. E. A. Thies, his son and the present manager, is following the same policy.

Spilsbury[c] gives the production of the Haile mine up to 1883 as over $1,250,000, and it has been said that the production since that time has been about $2,000,000, making the estimated total production about $3,250,000. As the company is a close organization, the amount of dividends paid is not known.

DEVELOPMENT.

The development of the Haile mine consists of a number of shafts, with drifts and crosscuts, and of three large open cuts. (See fig. 8.) The deepest shaft is the No. 4 shaft of the Cross workings, 350 feet deep, with levels at depths of 200, 270, and 350 feet. The bottom of the No. 2 shaft connects at the 200-foot level. The drifting from these two shafts amounts probably to 3,500 feet. A 130-foot winze has been sunk from the 350-foot level, east of the No. 4 shaft. An old shaft at the Beguelin workings is about 180 feet deep and has two levels aggregating about 1,200 feet. No. 5 shaft, to the west of No. 4, is 100 feet deep, with short levels at 60 and 100 feet. The Chase Hill shaft is also about 100 feet deep. There is a 60-foot shaft on Red Hill, northeast of the Cross workings.

The principal open cut is the Haile pit, about 250 feet long and 200 feet wide by 180 feet deep. A diabase dike crosses the middle of this cut and, being barren, has been left in place to serve as a pillar. On the east side of this dike open cutting was carried down about 100 feet and then the cut was filled with waste. The west side, called the new Haile pit, is being worked at present at a depth of 180 feet, a chute connecting to a short intermediate level at 185 feet, and thence to the 200-foot level of the No. 2 shaft, where the ore is hoisted.

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[a] Lieber, op. cit., vol. 1, p. 60.
[b] Lieber, op. cit., vol. 1, p. 62. Lakes, A., Mines and Minerals, vol. 21, 1900, p. 56.
[c] Trans. Am. Inst. Min. Eng., vol. 12, 1884, p. 102.

The Bumalo cut, 300 feet long and 100 feet wide, lies just east of the Haile cut. It is about 100 feet deep, but is connected and practically continuous with large underground stopes which reach below the 270-foot level. The Beguelin cut, 1,500 feet northwest of the Haile cut, consists essentially of two pits, about 120 feet deep, separated by a wide dike of diabase. The eastern pit is 200 feet long by about 125 feet wide; the west pit is about 120 feet square. Considerable prospecting has been done by diamond drills and well-drilling machines, of which a fuller description is given on page 86.

Among the surface developments may be mentioned a narrow-gage steam tramway connecting mines and mills, a 60-stamp amalgamation and concentration mill, and a barrel-chlorination mill, in addition to shaft houses, office buildings, etc.

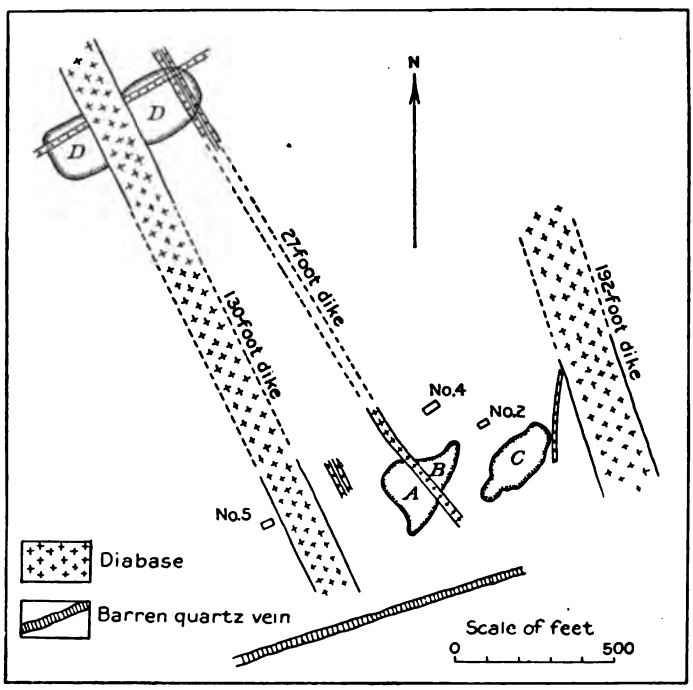


FIG. 8.—Sketch map showing location of the principal ore bodies of the Haile mine. *A*, New Haile pit; *B*, Old Haile pit; *C*, Bumalo pit; *D*, Beguelin pit.

GEOLOGY.

The geology of the Haile mine has often been described, but seldom in detail. Becker [a] and Nitze [b] give the best descriptions. The country rock is a quartz-sericite schist and is described petrographically on pages 15–16. The microscope shows it to have been derived by foliation from a porphyry tuff, probably granite porphyry tuff or quartz-monzonite porphyry tuff.[c] These tuffs were well bedded and this structure is preserved in some places. About 300 feet northeast of the chlorination mill the tramway cut exposes the tuff very plainly bedded in thin layers which on decomposition have assumed different colors, causing the banding to appear prominently. At this particular spot the rock has suffered only slight foliation, so that although it possesses a recognizable fissility the banding has been scarcely disturbed. Tiny cubical cavities lined with limonite indicate that pyrite was

[a] Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 306–308.
[b] Bull. North Carolina Geol. Survey No. 10, 1897, pp. 125–126.
[c] Cf. Becker, loc. cit.

once present. On the 60-foot level of the No. 5 shaft the same rock is seen in an unoxidized state. It is light gray in color, fairly soft, and exceedingly well bedded, so that thin layers can be separated from it. Under the microscope it is found to be somewhat silicified and pyritized. Remains of original bedding are easily recognizable in very siliceous ore from certain parts of the Haile and Beguelin cuts.

This tuff is composed of fragments of almost microscopic size. The assortment is nice, larger grains of quartz, feldspar, or mica being only rarely present, and it is in consequence natural to conclude that these are water-laid deposits. In this place in the No. 5 shaft some masses have almost entirely escaped shearing and the banding is perfect. From this extreme can be traced every gradation, through areas showing a slight disturbance of the bands and those in which remains of the banding is barely visible to dense rock with marked fissility or foliation and no indication of original bedding. In all places where bedding has been observed the foliation due to subsequent movement has been in general parallel to the original bedding planes. Minor local exceptions occur, the schistosity being oblique to the bedding. In several such instances the rock has a decided foliation across the bedding and yet the movement which produced this foliation was of so slight an amplitude that it requires a second look to be sure that the beds are faulted at all. Foliation or fissility is as well preserved in some of the silicified ore as in the less altered schist, but in general the soft sericitic rocks possess much more decided schistosity than the dense siliceous ores.

Of the few feldspar fragments which can be identified with certainty, no further classification can be made. Alteration has in most cases changed the feldspar fragments into sericite. When the rock has been foliated this fibrous mica gives a silvery luster to the cleavage surfaces and has led to the application of the name talc schists to these rocks. As a matter of fact, these rocks do not contain talc, as has been pointed out by Nitze,[a] who cites the following analyses by Baskerville:

Analyses of quartz-sericite schist from the Haile mine.

	1.	2.		1.	2.
SiO_2	44.61	61.02	Na_2O	6.96	2.19
Al_2O_3	31.57	25.54	K_2O	6.97	1.81
FeO	3.55	4.46	H_2O	5.80	4.20
CaO	.20	.60		100.04	99.96
MgO	.22	.14			
MnO	.16	.....			

The difference in these two analyses is probably not to be attributed to initial dissimilarity of the rocks, but rather to the fact that the fairly unaltered sericite schist, represented by analysis No. 1, has been silicified to the extent shown by No. 2. This silicification, which can be well represented by specimens and thus studied under the microscope, proves generally to correspond in intensity with the amount of foliation, although in the case of extreme silicification traces of former structure have been quite destroyed and the rock is simply a massive, siliceous "hornstone." Pyrite is a common constituent of all these phases of rock and in a general way corresponds in amount with the degree of silicification. This conclusion is reached only after microscopic study, for in the soft, less siliceous schists the pyrite occurs in crystals of a size readily detected by the eye, while in the hard silicified rocks it is present in abundance, but in such exceedingly minute crystals that they appear small even under a high power. These schists strike N. 40° to 60° E. and dip from 45° to 80° NW. (See Pl. V.)

Massive granite, similar to that in the tin belt farther west, is exposed about 2 miles northeast of the mine and may occur, covered by soil and sands, at a considerably less distance.

[a] Bull. North Carolina Geol. Survey No. 3, 1896, p. 34.

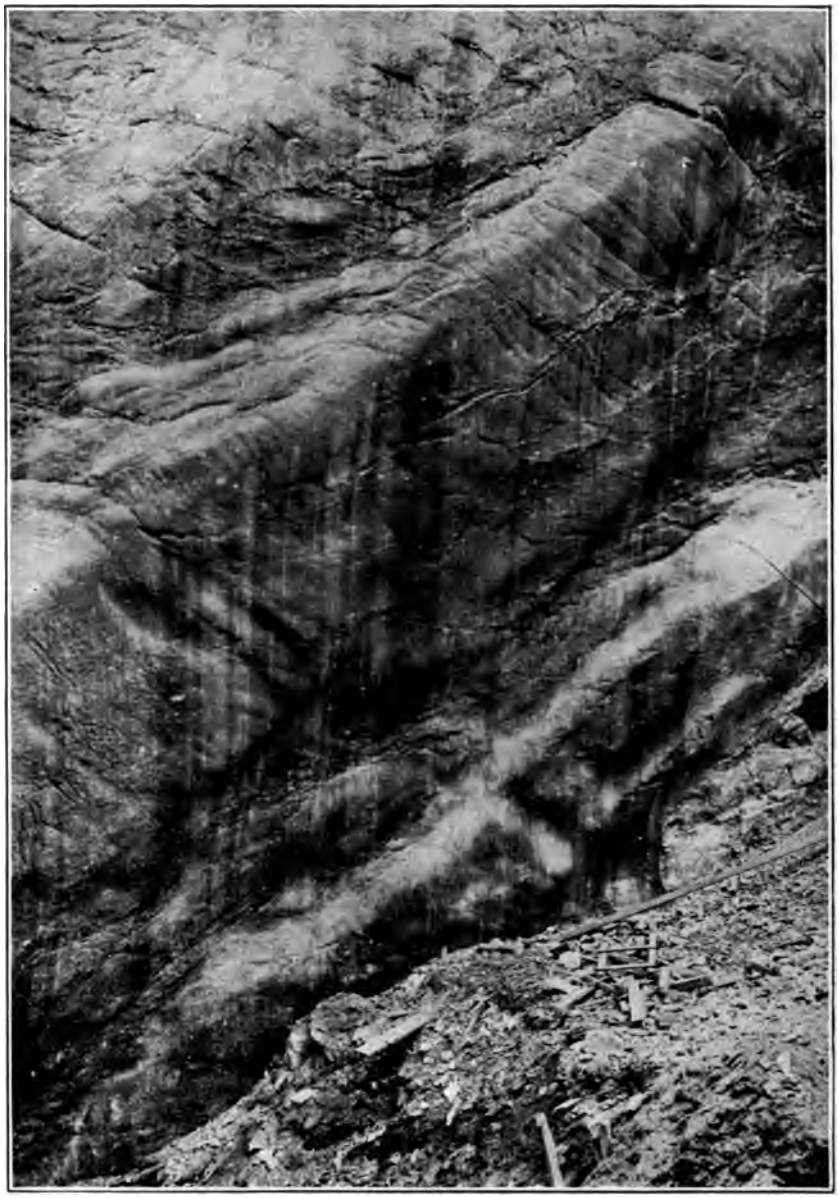
Several dikes of diabase close to the mine workings strike north-northwesterly across the foliation of the schist. (See map, fig. 8.) These are approximately vertical. A small decomposed diabase dike east of the Bumalo pit has a northerly strike and a steep dip to the east, and a narrow dike of diabase, also decomposed, exposed in the Beguelin cut, is parallel to the foliation of the surrounding rocks. (See Pl. VI.) In the description of the ore bodies, these dikes will be referred to and designated by their width, which is given on the map. In the Haile pit, as has been said, the ore has been mined away from the 27-foot dike, leaving it standing up as a partition between the two sides of the pit. In the new pit a side fully 150 feet square is exposed (Pl. IV). Near the surface this exposure affords a good example of the formation of residual soil. In the lower portion the dike has an uneven wall, the surface being billowed and looking shriveled or folded, much like an elephant's skin. The larger irregularities are rudely parallel corrugations and indicate the dip of the inclosing schists. The appearance of the dike suggests that it was intruded when the surrounding rocks were in a plastic condition, which certainly was not the case. Along the walls of these diabase dikes the miners find a layer of soft, muddy material which they term a "binder," and which doubtless represents an outer zone of decomposition. This binder is removed at the same time as the ore. It may be that the varying thickness of this decomposed portion has caused the irregularities in the surface of what remains, but if that is the case it is difficult to understand why these irregularities correspond with the dip of the schist. It seems more probable that the fracture through which the molten diabase came was influenced by the structure of the rocks in which it formed and hence did not develop along a perfect plane, but as an undulating crack. A petrographic description of the diabase of the region is given on page 23.

Where crosscuts and drifts penetrate these dikes away from the ore bodies, there is little alteration of the quartz-sericite schist at the contact with the diabase. The schist is baked or hardened a little for a few inches from the dike and shows a slight sheeting parallel with and close to the dike. Surface waters have been able to follow the crevice between dike and schist and have oxidized both rocks to a small extent. The diabase has usually suffered most in this respect. Small crystals of gypsum occur in the joints of both rocks where this oxidation has been moderate. Where the dikes cut the silicified schist of the ore bodies, the changes which they cause are even less marked and are practically negligible. There is no noticeable difference in the character of the diabase where it cuts the barren, unsilicified schist and where it breaks through the silicified rock of the ore bodies.

CHARACTER AND OCCURRENCE OF THE ORE.

The ore bodies of the Haile mine typify the class of replacement deposits previously described. They consist of large lenses of altered tuff which has been subjected to certain changes in composition. This alteration is of comparatively simple nature, consisting mainly of a silicification and pyritization of the porous tuffs. In most cases these two processes appear to have gone on simultaneously, so that although the pyrite is the mineral which carries the greater portion of the gold, the degree of silicification usually corresponds so closely to the degree of pyritization that it is commonly accepted as a rough measure of the richness of the ore. Soft, unsilicified schist is an unwelcome discovery, while rock so silicified that it will strike fire under the hammer is always looked on as a favorable indication. In general, the distribution of these replacing minerals is fairly uniform, producing a hard, bluish ore, usually with a lustrous fracture, due to the sericite, and containing disseminated pyrite, of which much is too fine in grain to be readily seen. Under the microscope this ore is seen to consist mainly of small polygonal grains of quartz with swarms of minute pyrite crystals, both cubes and octahedrons, scattered all through; sericite shreds and occasional fragments of biotite and remnants of a feldspar individual occur between the quartz grains. The rock which has suffered most intense silicification is a fine-grained aggregate of quartz and pyrite, with sparing fibers of sericite.

Here and there the replacement of the original rock has not gone on evenly. Light-colored veinlets, occurring either singly or in numbers, closely spaced, probably represent



SIDE OF DIABASE DIKE EXPOSED IN THE HAILE PIT.

Major corrugations represent dip of ore-bearing rock which has been mined away. Vertical streaks due to water stains.

very narrow fractures which allowed an especially easy passage for the solutions and consequently the extreme silicification of the adjoining rock. In a few instances these crevices have been wide enough to allow the deposition of quartz filling in addition to the replacement which has occurred along the walls. A few of these quartz veins are outside the limits of the ore bodies and nearly all of them carry little or no values. It is possible that they were formed a little later than the general silicification which produced the ore bodies. A large, worthless vein of this sort outcrops strongly back of the stamp mill, and is shown in fig. 8. A smaller vein or lens, practically barren, is encountered in the Bumalo cut.

There are likewise places where the deposition of pyrite has been especially marked, producing masses which in some cases are nearly solid sulphide. These, too, are usually tabular in form, but can not be definitely referred to fractures, as can the quartz veins. Bodies of this kind, rich in pyrite, associated with molybdenite (heretofore assumed to be graphite) and carrying good gold values, occur near the hanging wall of the Haile ore body in the new Haile pit. The molybdenite occurs especially along narrow parallel bands in the pyrite and shows the effect of sliding motion, or slickensides. Gold occurs free on these smooth surfaces of the molybdenite in excessively thin flakes, which seem to have been deposited before motion ceased. Pyrrhotite occurs sparingly in some of the Beguelin ore. An irregular bunch of pyrite, said to contain a considerable proportion of zinc, but only a small amount of gold, was found at the northeast end of the Beguelin pit, at a depth of about 75 feet.

Gold occurs in three conditions in the Haile ores—native gold as originally deposited, free gold derived from the oxidation of inclosing pyrite, and gold in the pyrite. In either of the first two states the gold can usually be recovered by amalgamation, although the gold freed by oxidation is sometimes "rusty," i. e., covered with a thin film of resistant material, perhaps iron oxide, which protects the gold from the mercury and thereby prevents amalgamation. In the unaltered pyrite only a small proportion of the gold is attacked by mercury and another process is required in order to save the values.

There is possibly still another way in which the gold occurs. Some specimens from the Beguelin cut, now in the Haile office, show thin flakes of gold in narrow cracks or joints in blue unoxidized rock. These specimens give the impression that the gold has been carried and deposited in these crevices by solutions later than the original ore solutions—probably by surface waters which have obtained the gold by dissolving it from the original ore. Thin sheets of pyrite, many of them with a radial structure, occur similarly in narrow cracks and likewise suggest secondary deposition. The free gold associated with molybdenite may also have been deposited in this way. It has been impossible to determine whether or not secondary enrichment, i. e., solution from upper portions and redeposition at a lower level, has actually taken place; but the possibility that such has been the case seems rather strong and has already been considered on pages 65–67.

Broken pyritic ore lying exposed to the air very readily undergoes oxidation, with the production of so much sulphuric acid that, to save the plates from injury, such ore is not amalgamated, but sent to the concentrators direct. In this case a narrow string of the liberated free gold leads the headings down the Wilfley tables. Oxidation underground is also proceeding rapidly, and in nearly every drift iron-laden waters are depositing layers of limonite. The comparatively small amount of water which the mine makes is held at the 350-foot level by pumping.

VALUE OF THE ORE.

The Haile is essentially a low-grade mine. Although rich nuggets have been found in the decomposed upper portions of the ore bodies, as already mentioned, and these upper portions as a whole doubtless held good values, the great bulk of the ore has been of so low a grade that the utmost care has been demanded in the extraction of the gold to make the operations profitable.

In 1883 the average value of the ore, which had been mined down to a depth of 75 feet, was estimated at about $11 per ton.[a] In 1887 the values were said to average $5 to $10, with $6 as a fair mean.[b] By 1900 $4 was considered to be the average gold content.[c] At the present time it is probable that the average value of the ore that goes to the mill is little if any above $3 per ton.

This marked decrease in value may be attributed to several causes. In the first place, there can be little doubt that the actual richness of the deposit has steadily decreased from the surface down. Second, instead of mining along certain rich places or zones, as was done in the early days, with resulting irregular workings, the mining now takes everything as it comes, rich and low grade alike, down to a certain limit of value. Third, reduced costs have made it possible to work at a profit ore which twenty or thirty years ago was worthless, and in consequence work is now deliberately carried into what would then have been considered the walls of the deposits. In some respects, therefore, the decrease in value of the ore is to the mine's credit, indicating that much more material is available for treatment than there could have been under the early conditions. The fact that the comparatively rich ore has been exhausted and that mining operations have been forced toward the outer limits of the ore bodies, however, is of course a state of things which no company could desire.

As for actual values of any given mass of ore at present, little information is to be had. Assays are not commonly made, and as a general rule the value of the ore is measured only by the recovery on the plates and by chlorination. As the ores from the several ore bodies are generally run through the mill promiscuously, it is difficult to determine the value of any one lot. When it is found that returns run below the line that separates profit from loss, steps are taken to determine which of the several localities where ore is then being mined is the cause of this decrease in value, and when this is known material from that place is not sent to the mill.

It is not meant to imply here that these operations are conducted carelessly. The various processes—crushing, amalgamating, concentrating, and chlorinating—have in the past been so carefully studied and so nicely perfected at this mine that it is believed that increase in percentage recovery would cost more than the value of the extra gold saved. With the total cost charged against the ore standing at about $1.60 per ton, it is doubtful if ore running much less than $2 is intentionally carried to the mill. In the Haile pit certain zones carrying heavy pyrite, considerable molybdenite, and some free gold carry $12 to $14 per ton, and at a depth of 200 feet, just below the bottom of the Haile pit, some $40 ore has been found. These values, $2 and $40, probably represent about the extremes at the present day.

When mining was begun at the Haile practically all the gold was free, since oxidation was complete near the surface. As near as can be learned, the water level was at about 60 feet. From that point downward sulphides have been increasingly important. In the nineties a check on the value of the ore was kept by frequent panning, the amount of free gold being approximately proportional to the total value of the ores. As greater depths were reached the proportion of the total value occurring as free gold decreased still further, and is now about one-fourth; and much of the ore now worked profitably shows no color in panning. Visible free gold in the coarse ore is rare. It occurs most commonly as thin flakes on the molybdenite in the Haile pit.

Pyrite ranging in amount from 1 or 2 up to 30 per cent of the ore is saved by the Wilfley tables. The value of the tailings is not known to the writer, but the extreme fineness of the pyrite grains makes it probable that an appreciable quantity of pyrite is lost. The loss in concentration a few years ago was said to be 15 to 20 per cent,[d] and was doubtless attributable in large part to this small size of the pyrite grains. The ore is concentrated

[a] Spilsbury, E. G., Trans. Am. Inst. Min. Eng., vol. 12, 1884, p. 101.
[b] Idem, vol. 15, 1887, pp. 770-771.
[c] Lakes, A., Mines and Minerals, vol. 21, 1901, p. 56.
[d] Nitze, H. B. C., Bull. North Carolina Geol. Survey No. 10, 1897, p. 137.

HAILE ORE BODY NEAR BOTTOM OF HAILE PIT.

Showing foliation and dip. Looking northeast.

about 12 to 1 on the average, and these concentrates are very clean, seldom containing over 15 and often under 10 per cent of rock. The pyritic portion of the concentrates is practically pure iron sulphide, with only a slight amount of copper and occasional traces of arsenic. These concentrates range in value from only a few dollars up to $40 and more per ton. Between 90 and 95 per cent of their value is extracted by the Thies process of roasting and chlorination. It is probable that the total extraction is a little under 80 per cent of the assay value of the ore.

A point to which the miners unanimously hold, but for which an adequate explanation has not yet been found, is the decided influence of joints on the value of the ore. This feature seems to be best illustrated in the Haile ore body, but is said to apply also to the Bumalo and Beguelin deposits. There are three fairly well-defined systems of joints in the ore of the Haile pit. One system, approximately vertical and at a right angle to the strike, has little or no effect on the values except at the southwest end of the body, where the joints appear to be the boundary of the pay ore. Joints parallel to the foliation of the rocks likewise have little influence on the values. Joints of the third system, running from foot to hanging wall perpendicular to the dip and called "floors," are said to have a decided effect on the values. For a few inches on each side of them, particularly on the under side, the ore is said to be better than elsewhere, and there is also said to be a difference in value between any two. These floors are well shown in Pl. V. They have every appearance of being of later formation than the ore, and why they should so affect the value is not known, unless secondary enrichment has taken place along them, and that is probably not the case.

ORE BODIES.

The most remarkable feature of the Haile mine is its large ore bodies. Some idea of the size of these has already been given in the description of the developments. Roughly outlined on the surface by the presence of float gold the principal ore bodies were at once recognized. Subsequent work has resulted in the three large open cuts—the Haile, Bumalo, and Beguelin pits. As the grade of ore which could be profitably treated progressed lower and lower, these workings have been extended into the outer portions of the deposits. All these principal ore bodies, which are lenticular in form, are influenced in their position by the structure of the rocks in which they occur. In other words, their longest horizontal dimension lies in a northeast-southwest direction, and they dip to the northwest.

The Haile ore body is an irregular lens of altered tuff whose foliation strikes about N. 40° E., and dips on the average 55° NW. This foliated structure is preserved in the ore, as well as in the unaltered tuff, and is well shown in Pl. V, which is a view toward the hanging wall of the new Haile pit near its bottom. If the field of the photograph extended a little farther to the right, the diabase dike shown in Pl. IV could be seen. Pl. V also shows incidentally the method of breaking the ore, which practically amounts to quarrying. The ore body following this rock structure is about 200 feet long from northeast to southwest, and on the average 100 feet thick at a right angle to the walls. From a description of the old Haile pit, now filled in and inaccessible, and from what can be seen underground, the northeast end of the deposit seems to narrow up, lens-like, till finally pay ore practically ceases. At the southwest, however, at least for the upper 200 feet, the boundary between pay ore and rock of too low grade to be worked is roughly a plane running approximately vertically across the deposit. There is in some cases even a joint or break at this place, on one side of which ore occurs and on the other practically worthless rock. This suggests the possibility of faulting along a plane parallel to the 27-foot dike, but there is no other evidence of such an occurrence. It is difficult, however, to explain the sudden cutting off of the values and of the alteration which produced them.

About 100 feet below the surface, at the southwest end of the pit, a small bunch of quartz occurred holding some free gold. At 130 feet, about midway between the foot and hanging walls, at the same end of the pit, a horse of well-foliated sericite schist, soft in comparison with the surrounding silicified ore, juts into the pit, and continues with the general dip as far as work has gone. Just northwest of this, or toward the hanging wall, the ore is heavily

impregnated with pyrite along a zone 2 or 3 feet wide. Narrow bands of molybdenite carrying free gold occur with the pyrite. This ore is said to run $12 to $15. Not far from the hanging wall is another similar streak.

The foot wall, exposed for practically the full width of the new pit, has a smooth, distinct surface with large horizontal waves or undulations. It is approximately parallel to the foliation of the rocks. Several crosscuts into the foot wall have demonstrated the absence of pay values beyond this surface. The line of demarcation between ore and waste is therefore rather sharp. Much of the hanging-wall rock has necessarily been broken to prevent its caving in. The nature of the transition from ore to waste is therefore not so well exposed as on the foot-wall side of the deposit. Crosscuts from the ore into the hanging wall give some idea of this boundary of the ore body, and while the change from ore to unprofitable rock appears to be less abrupt than on the foot wall, nevertheless the values decrease rapidly away from the present stopes. These facts mean that no matter how much the processes of winning the gold are cheapened in the future, the limits of this ore body are already set, so far as lateral extent is concerned. Similar conditions exist in the Bumalo and Beguelin bodies. Less satisfactory evidence leads to the same conclusion regarding the longitudinal extension of future pay values. In depth, too, it is plain that the various ore bodies are not indefinite. In the Haile body some very good ore, running as high as $40 per ton, has been found at the 200-foot level, a little below the present bottom of the Haile pit. Some stoping has been done between the 200-foot and 270-foot levels on the Haile ore body, and more ore from pillars and from the lower-grade periphery can probably be taken out profitably when the open cut reaches that depth. But below the 270-foot level the values are low, and unless relatively rich pockets or lenses are discovered the time must be expected when the ore will become so lean that with the increasing cost as depth is attained it will be impossible to mine with profit. A drift on the 350-foot level runs under the continuation of this ore body and encounters material carrying values that are appreciable, but too low to pay for mining. It appears, therefore, that the ore body has a greater extent downward than horizontally, but it seems likely that the limit of workable ore includes much less ground.

In the Bumalo ore body the principal differences from the Haile are those of dimensions. The main portion of the cut, about 250 feet long, is lagged over at a depth of about 100 feet, and thus separated from stopes which continue downward almost 200 feet farther. This ore body, striking about northeast and dipping to the northwest at a little lower angle than the Haile body, has a decided pitch north-northeast in the plane of foliation. It is narrower than the Haile deposit, averaging perhaps 40 feet perpendicular to the walls. A large quartz lens near the surface is inclosed in the ore body. It is practically barren, although the miners believe that the ore near it is a little richer than at a distance. At a depth of 15 feet a northeasterly drift was run from the end of the Bumalo cut. Low-grade ore was encountered as far as the 192-foot dike. The drift was continued through the dike, but no ore was found on the east side. A small diabase dike with northerly strike occurs just east of the main workings. It is much decomposed and does not carry values. A big stope on the 200-foot level is now inaccessible. On the 270-foot level uneven distribution of the values has resulted in irregular stopes, both steep and flat, separated by large and small pillars of lower-grade rock. Pay ore was found to stop about 25 feet below the 270-foot level. The pitch of the deposit has carried it to the 192-foot dike on this level. The 350-foot level explores the continuation of this ore body. Appreciable values are encountered where the ore would be expected, but nothing of workable grade has been found. Just west of the 192-foot dike a 130-foot winze has been sunk, inclined northward at 75°, in the hope of striking a new pay shoot, but only low-grade values were found. The 350-foot level continues on through the 192-foot diabase dike, but fails to reach ore. The position of the narrow diabase dike on the east side of the 192-foot dike shows that little or no faulting has taken place along the latter.

In view of the recumbent position of this ore body, necessitating the removal of much waste from the hanging wall, the extraction of the material remaining below the 200-foot

BEGUELIN ORE BODY, HAILE MINE.

Showing dip and interfoliated diabase dike now decomposed. Looking west.

level as pillars and as low-grade boundaries will be increasingly expensive by continuation of the open cut. Fig. 9 shows the distribution of values in the Bumalo cut.

The Beguelin ore body is in general character similar to the two already described. It is cut in two by the 130-foot dike without faulting. Ore extends along the strike of the schists about N. 60° E. for nearly 300 feet on each side of the dike. Near the northeast end of the ore body the 27-foot dike, which has split, crosses the ore. Just outside the ore body, in the hanging wall, a 3-foot dike of much decomposed diabase, called a "clay" dike, parallels the strike and dip of the ore. Pl. VI gives a view of this interfoliated dike as exposed at the southwest end of the pit. The average thickness of the Beguelin deposit is about 70 feet. In depth the ore reaches to about 170 feet, and there quickly drops off in value. Most of the richest ore was taken out to this depth by underground workings. Open cutting was then begun. The open cut east of the dike is 160 feet deep and has practically exhausted that end of the ore body. At the northeast end, perhaps 40 feet below the surface, were found the specimens showing free gold in the joints described on pages 63 and 64. About 50 feet northeast of this place and 35 feet deeper a small body of heavy pyrite, carrying some zinc, was struck, and 100 tons were shipped for the manufacture

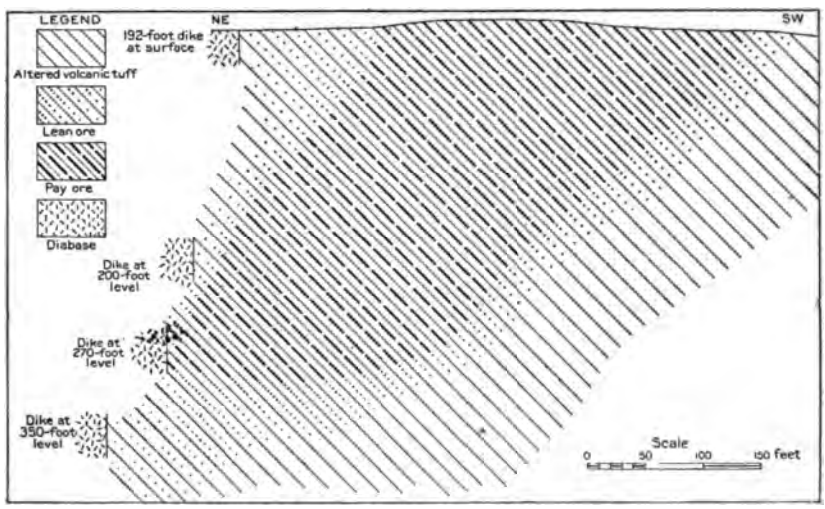


FIG. 9.—Longitudinal projection (approximate) on plane of deposit of the Bumalo ore body, Haile mine.

of sulphuric acid. On the southwest side of the dike the open cut had been carried to a depth of 120 feet at the time of visit, and had almost reached the southwestern limit to which underground mining had been carried. (See Pl. VII.) Still farther southwest of this point for over a hundred feet values are encountered, but they are so low that it is doubtful if mining can be extended there. The demarcation of this material from the surrounding rock, however, is such as to place it as part of the ore body, and it has so been shown in fig. 10.

Silicified and pyritized tuff carrying gold values is known in several other places. Assays have been obtained at several points northwest of the Beguelin pit, but up to the present time no further prospecting has been done in that locality. On a small elevation known as Chase Hill, several hundred feet northeast of the Beguelin cut, some shallow open pits have been dug on siliceous rock, with numerous quartz-rich streaks. Pyrite, once plentiful, has been mostly oxidized and carried away, leaving the rock crumbling and stained. The strike of these pits is in direct line with that of the Beguelin, and it seems highly probable that the two ore bodies are connected by a band of lower-grade material somewhere underground if not at the surface. The Chase Hill deposits, although explored underground as

well as by surface workings, have never been important producers and are not now being worked. On Red Hill, 500 or 600 feet northeast of the Bumalo pit, considerable ore was once mined from open cuts reaching down to the limit of complete oxidation—about 60 feet. The body here, a lens which lines up well with the Haile deposit, has a maximum thickness of 100 feet. Considerable exploration in the way of diamond drilling and well drilling has been carried on here recently to determine if lower portions of this deposit would constitute profitable ore, but the writer learns from Mr. Thies that the values encountered were not very high and exploitation has ceased. It may be remarked here that 6- to 10-inch wells drilled by machines of the Keystone type have been found at this mine to be decidedly cheaper for holes down to 500 or 600 feet than diamond drills, and that the bailed drillings give a much more satisfactory indication of the values passed through than do diamond-drill cores.

About 150 feet northwest of the Haile pit the 185-foot level entered much jointed and fractured silicified rock which carried no visible free gold but averaged $8 per ton on assay. This body, about 30 feet in diameter, extended about 40 feet above and 25 feet below the level. A raise to this body from the 270-foot level passed through several streaks of $5 ore. Thirty feet west of the northwest corner of the Haile pit an old level 115 feet below the surface encountered $3 ore in amount too small to warrant extraction. On the 200-foot

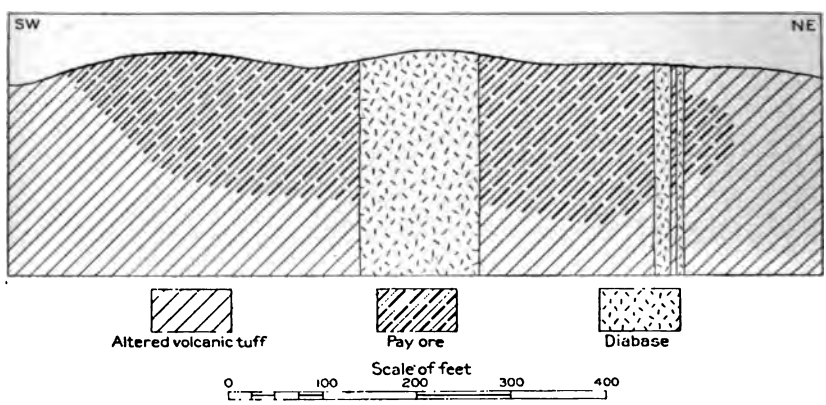


FIG. 10.—Vertical section (approximate) of the Beguelin ore body, Haile mine.

level, about 100 feet northeast of the No. 4 shaft, 75 tons of ore exhausted a small body occurring near but apparently not related to a quartz vein.

At a depth of 20 feet the No. 5 shaft reached ore assaying $4.50 per ton. This proved to be the top of a chimney-like body 15 feet in diameter, which ceased at a depth of 42 feet. A northeast crosscut from the bottom of the 100-foot shaft extends for 130 feet through material assaying 50 cents to $2 per ton and then reaches a practically barren hanging wall. The values are too low to warrant further development of this body. A well 400 feet deep about midway between the Haile and Beguelin pits gave evidence of quartz and silicified schist carrying pyrite with traces of gold.

A recent letter from Mr. E. A. Thies, manager of the mine, reports the discovery of a new ore body about 300 feet southwest of the 130-foot diabase dike on the continuation of the strike of the Beguelin deposit. Twelve holes have been drilled and indicate that the values rapidly decrease below 140 feet. Two hundred feet farther to the southwest drill holes indicate the presence of a large decomposed diabase dike cutting across the rock structure.

This new ore body, with the Beguelin and the Chase Hill pits, constitutes a zone almost 1,500 feet long, parallel to the foliation of the country rock and at a right angle to the main diabase dikes. This, it seems to the writer, is another argument against the existence of a

BEGUELIN ORE BODY, HAILE MINE.

Showing old levels and stopes exposed by open cut. Looking southwest.

genetic relation between the dikes and the ore. This subject is more fully discussed on pages 70–72.

While considerable ore of workable grade remains in the ore bodies now developed, the new deposit recently discovered and others like it must be looked to if the mine is long to continue as an important producer. It may be that ore bodies possibly of equal grade with those already known exist along the same general zone at greater depth, but it is not so probable that they can be discovered and worked at a profit. The possibility that secondary enrichment has effected the value of the known deposits is too uncertain to allow prediction as to the value of bodies below the surface. Of the bodies which reach the surface, it is probable that the richest are already known, but it is reasonable to believe that along the strike of these known deposits others of workable grade exist and might be discovered by careful surface prospecting.

COLOSSUS MINE.

The Colossus mine is situated in Union County, N. C., about 4 miles south of Waxhaw, on the Seaboard Air Line, and about 3 miles from the South Carolina line. Until recently it was called the Howie[a] or Huey[b] mine, and was once known as the Cureton mine.[c] At one time it was one of a group known as the Grand Union Gold mine.[d] It was worked certainly as early as the fifties and probably earlier than that. Before the war Commodore Stockton owned and operated the mine and it was sometimes known as the Stockton mine. Considerable ore was taken out at that time. About fifteen years ago the mine was again worked and the production considerably augmented. Some three years ago a company began to cyanide the amalgamation tailings from former operations. The Colossus Gold Mining and Milling Company now has control of the property and was working rather extensively at the time of visit, This company has its head office at Nazareth, Pa., and Mr. William B. Shaffer is manager.

No definite information is to be had regarding the production of this mine. Some say that a million has been produced, others half a million. In 1856 it was stated that the profit per month was $18,000 to $20,000 clear.[e] The cyaniding operation of a few years ago is said to have yielded $36,000.

The development consists of four shafts with rather short levels and several trenches. The Bull Face shaft was started as an incline, but fifteen years ago it was made vertical and carried to a depth of 160 feet. Later an incline was started from the 120-foot level of the vertical shaft and carried downward about 200 feet, so that the total depth of the shaft is about 320 feet. Only a small amount of drifting has been done. Active pumping had lowered the water to 220 feet in November, 1904. The Old Nettie and the New Nettie shafts, both sunk under former management, are nearly filled with water and are much caved. It is said that the New Nettie shaft is over 300 feet deep. The Pansy shaft, which was put down by the present company, is 104 feet deep and has perhaps 200 feet of drifting and crosscutting at its bottom. An old open slope or trench exposes the upper portion of the ore body.

In the way of surface development there is a small hoisting plant over the Pansy shaft, besides office buildings, assay office, etc. A 500-ton cyanide plant was well under construction at the time of visit. It is the intention of the company to work the mine as a large open cut, to break the ground by quarrying methods, raise and carry the ore in buckets by an aerial tramway reaching to the mill, dry crush by rolls to 30 mesh, and leach with cyanide in large vats.

The geology of the Colossus mine is very similar to that of the Haile. Foliated quartz-sericite schists retain enough of their original character to show that they were porphyry

[a] Emmons, E., Geol. Survey North Carolina, 1856, p. 133.
[b] Lieber, op. cit., vol. 1, p. 56.
[c] Kerr and Hanna, Ores of North Carolina (chap. 2 of Geology of North Carolina, vol. 2), 1893, p. 237.
[d] Kerr and Hanna, op. cit., p. 261.
[e] Lieber, op. cit., vol. 1, p. 43.

tuffs. Fragments of feldspar—microcline, microperthite, and plagioclase—and of brownish biotite are readily discernible in most of the microscopic sections of the rocks. The foliation of these schists, which appears in all cases to represent original bedding, strikes N. 55° to 65° E. and dips northwest at an angle of almost 90°. These schists have been silicified along certain bands which appear to represent shear zones. Where unoxidized, the resulting siliceous rock is dense and bluish, with lustrous cleavage faces almost identical with the Haile ore except that at the Colossus the banding is generally better preserved. A pronounced jointing has taken place, evidently since the silicification of the schists. These joints dip 80° to 90° SW. and strike about N. 35° W. Along these principal joints several dikes of diabase of similar character to that at the Haile mine have been intruded. They range in width from 5 to 8 feet. These joints and dikes often fault the ore body. One dike to the northeast of the principal mine workings is said to displace the vein 300 feet laterally. It is said that in the case of all these faults the northeastern side is thrown to the northwest. The "Monroe" beds, which are known to exist a few miles to the northeast, have evidently been eroded away in the immediate vicinity of the Colossus mine and certainly have no connection with the ore.

This mine is another excellent example of the replacement deposits of this region. The ore is decidedly similar to the Haile ore. It is hard, blue, siliceous rock, usually with decided fissility or cleavage, and contains pyrite. As at the Haile mine, ore is limited to the silicified portions of the schists. Small quartz stringers, usually parallel to the foliation, give the impression of almost complete replacement by silica of the rock adjoining narrow fractures. Pyrite is a little more abundant near these stringers than elsewhere. The zones of most intense silicification in general constitute the best ore. They exhibit a decided sheeting parallel to the original foliation and doubtless owe their existence to the fact that the ore-bearing solutions found readiest channels along sheeted zones. Oxidation is also more advanced along these sheeted zones than elsewhere, owing, without doubt, to the more easy penetration of solutions which they allow. Pyrite is less abundant and more evenly distributed through the ore than at the Haile mine and no molybdenite has been seen.

The condition of most of the gold is a matter not definitely established. It is said at the mine that the greater part of the gold is free and also that there is very little pyrite present. The fact that mining was carried on fully 200 feet below the water level when amalgamation was the only means of extraction employed would seem to strengthen this statement. The writer saw numerous specimens containing free gold, but all of them had suffered oxidation and in all the gold had the appearance of having been derived from pyrite. While it is true that pyrite is not abundant, it is present in tiny grains all through the ore, in amount ample to contain all the gold which the assays show. A possible explanation of the presence of free gold below the water line may be found in an occurrence near the bottom of the Pansy shaft. Joints and crevices along which water from the surface travels with more or less ease show the effects of oxidation; the adjoining rock is stained brown or red and a red slime oozes down the walls. The ore is usually better near these places than elsewhere. Away from visible fractures of any kind, the hard, unstained blue rock is often found to be porous, containing many minute cavities which correspond in form to pyrite crystals. Some of these cavities are partially filled with a light-colored crystalline substance which proves to be at least in large part ferrous carbonate. It is evident that some kind of solution, which probably means some kind of oxidation, has attacked the pyrite. It is equally evident that waters carrying dissolved oxygen, like the ordinary surface waters, have not been active. It is possible that the pyrite has been oxidized and converted into a sulphate by sulphuric acid, or ferric sulphate, or both. Such a reaction may have necessitated the liberation of free sulphur or of sulphur dioxide, although evidence of neither of these was seen. It was impossible to decide how widespread this phenomenon has been, and free gold has not been detected in the cavities originally occupied by the pyrite; but it is possible that gold could in this way be liberated from the inclosing sulphide and form a free-milling ore below the limit of ordinary oxidation.

The fact that of the ore milled during the former working of the mine a large percentage was not recovered is to the writer's mind an indication that considerable of the gold was contained in pyrite. On many of the numerous minor joints flat scales of pyrite occur, some of them with a rudely radiating structure. These fractures and the pyrite in them have almost certainly been formed subsequent to the principal deposition of quartz and sulphide. This occurrence of pyrite is rather common in or near the porous rock from which pyrite has been removed and is perhaps a redeposition of the actual material which constituted the original pyrite crystals. Where oxidation has been marked, small flakes of gold are frequently found on joint faces, only loosely attached to the rock and presenting the appearance of having been derived from this probably secondary pyrite. If such is the case it would seem to argue in favor of secondary enrichment, or at least solution and redeposition of gold comparable to the secondary enrichment of copper.

The ore which has been mined from the Colossus mine has probably been of higher grade than that taken from the Haile mine. That near the surface was rich, some of it running over $200 per ton.[a] In the later work the ore is said to have averaged about $15 per ton.[b] The tailings recently worked by cyanide had doubtless been subjected to some concentration by the action of the water which discharged them from the mill and by subsequent rains. They are said to have yielded from $3 to $15 of gold per ton. These values are not justly comparable with those at the Haile mine, for there the bodies of ore worked have been extended to the greatest possible size by including rock of lower and lower grade, while up to the present only the richer shoots, much smaller in size, have been mined at the Colossus. Assays made by the present company are said to run from $2 to $2,000. The rock broken in sinking the Pansy shaft is said to have averaged $8. As this is near the middle of what is considered the ore body, it is probable that the average value of the deposit will run somewhat under that figure. Lieber, writing in 1856,[c] states that the gold was worth 87½ cents per pennyweight, which, on the assumption that the accompanying material was silver, would make the fineness of the gold about 0.840. Of the $36,000 extracted by cyanide, about $1,100 is said to have been silver, making the fineness of the gold recovered from the old tailings about 0.435. It is stated by Professor Hanna, who made many assays of this ore, that the fineness ranged from 0.725 to 0.775.[d]

The old stopes are not extensive. A chimney-like ore shoot in the Bull Face workings was followed by the incline shaft. It pitches about 75° NE. At a depth of 140 feet the stope on this ore shoot is 20 feet wide and 40 feet long. From 140 down to 220 feet the stope ranges from 20 to 30 feet in diameter. Below that depth—the water level at the time the mine was visited—the size of the stope was not known, although it is said that when the old work was stopped there was ore in the bottom of the shaft and ore was left on the northeast side of the stope. The value of the rock forming the walls of this old stope was not learned by the writer. Of the stopes in the other old shafts practically nothing is known at present. They probably followed shoots similar to that in the Bull Face.

The Colossus Company has control of 10,000 feet along the strike of the deposit, and gold is known to occur at intervals throughout this extent, but adequate prospecting has been done on very little of the property. The portion which the company expects to mine at present is said to be 400 feet wide and perhaps 800 feet long. This body, approximately vertical, is parallel in its long direction to the foliation of the schists. At the bottom of the Pansy shaft crosscuts in each direction have been run about 100 feet. They show narrow strips of soft, almost barren rock, which separates zones of ore, but which are of so small bulk that it is the belief of the company that the whole may be mined and milled. In the writer's opinion—based, it is true, on a hasty and superficial examination of the deposit—exploration has not yet been sufficient to warrant so extensive preparations for milling as are being undertaken. It is questionable, moreover, if the straight cyanide process to be employed will sucessfully treat this sulphide ore.

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[a] Emmons, E., Geol. Rept. Midland Counties of North Carolina, 1856, p. 1314.
[b] Cf. Nitze and Hanna, Bull. North Carolina Geol. Survey No. 3, 1896, p. 105.
[c] Op. cit., vol. 1, p. 57.
[d] Kerr and Hanna, Ores of North Carolina (chap. 2 of Geology of North Carolina, vol. 2), 1893, p. 235.

BREWER MINE.

The Brewer mine is situated on a branch of Lynch River, in Chesterfield County, S. C., about 4 miles southwest of Jefferson, on the Charlotte, Monroe and Columbia branch of the Seaboard Air Line. It is about 10 miles northeast of the Haile mine.[c] The property is being worked by Mr. B. J. Hartman, under lease from the De Soto Mining Company.

This was probably the first important producer in South Carolina,[a] and is even believed by some to have been worked before the Revolutionary war.[b] In 1830 and 1831 from 100 to 200 men were employed daily.[c] The first work was placer operations at what was known as the Tanyard deposit, which lies to the east of the present workings. Later, placer methods were applied to the decomposed portions of the deposits in place. Just before the civil war Commodore Stockton worked the mine and extracted the gold in Chilean mills and arrastres.[d] In the early eighties the Tanyard gravels were worked again, this time by hydraulicking. A 5-stamp mill was erected in 1885, in 1889 a 40-stamp mill was put in, and in 1892 a Thies chlorination plant was added, but continued in operation only a short time. It is said that the bringing of damage suits arising from tailings débris was one cause of cessation at this time. Spasmodic attempts, including some experimentation with the cyanide process, have since been made to resume active operations, but have brought little success. At present the mine is being worked on a small scale and the ore put through a 10-stamp mill with simple amalgamation. About half a dozen men comprise the force.

No idea of the production of this mine can be given. In the early days, when the output was probably at its greatest, no figures were made public. Probably several hundred thousand dollars have been taken from the mine.

The principal developments consist of two great open cuts. The old main pit is 140 feet deep and 200 to 300 feet in diameter. A tunnel extends eastward from the bottom 1,200 feet and leads to the mill near the river. Other tunnels or drifts have been run in various directions from the bottom of the pit. Several short levels, raises, and stopes make an irregular network underground, especially at the west side of the pit. About 500 feet southwest of this pit is another, more than 100 feet deep and about 150 feet in diameter. There is some thought of sinking this to the level of the bottom of the larger pit and connecting the two by a crosscut. In addition to these large cuts there are several shallow shafts and pits. The 40-stamp mill is in fair condition, but the chlorination plant has been demolished. The 10-stamp mill now being used is not well housed.

All geologists who have studied the Brewer mine have realized the difficulty of obtaining satisfactory knowledge of it. It is certain that porphyritic rocks, in part tuffaceous and brecciated, have been acted on by silica- and ore-bearing solutions. The rocks thus acted on differ so greatly from those which have escaped most of this action that it is difficult to decide if they were originally the same. The conclusion which seems most in accord with the facts is that all was once the same rock, but that intense brecciation, amounting almost to pulverization, affected some portions and left other masses only a little shattered. Then, when solutions sought to permeate this mass, they found easiest passage in the fragmental portions and there expended almost all their chemical and physical energy. The rock which remains least altered is a light-colored, fairly coarse-grained porphyry, with a small proportion of groundmass. The only recognizable original constituents are sparing grains of quartz and abundant phenocrysts of a mineral whose identity has not yet been established.[e] The quartz is penetrated by numerous prismatic crystals, apparently of secondary origin, possibly topaz, and the unknown mineral is in the majority of cases

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[a] Cf. Lieber, op. cit., vol. 1, p. 67.
[b] Kerr and Hanna, op. cit., p. 234.
[c] Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 257.
[d] Cf. Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 145.
[e] Dr. W. F. Hillebrand is now working on the analysis of this mineral. The purest material which has been separated has the maximum specific gravity of topaz, 2.57. Analyses of less pure portions show that the mineral has the same percentage of silica and alumina as topaz, but appears to contain less fluorine. In addition to this chemical disparity, the optical properties differ markedly from those of topaz. It may very well be, therefore that this is a new mineral. It is hoped that definite information on this point will soon be obtained.

much decomposed into sericite. Dark grains of a nonmagnetic titanium mineral are closely associated with this fluorine mineral. They may be ilmenite. Pyrite is present in crystalline grains impregnating both constituents. These less altered portions are practically valueless and have been left in place as the ore has been mined away from them. They are known as dikes. In all cases observed, however, they have no distinct walls, but gradually pass by increase of shattering and silicification into the dense bluish rock which constitutes the ore. On the surface this silicified ore is stained red from oxidation of the iron and well shows its brecciated character. Narrow veinlets of quartz, carrying a little pyrite, cut both the highly silicified and the little altered rock. In the former they seem to fade off into the surrounding rock; in the latter their walls are distinct, and along with and close to the pyrite they hold radiating masses of pyrophyllite. It certainly appears as if the three minerals—quartz, pyrite, and pyrophyllite—were contemporaneous.

Granite is known to occur about three-fourths of a mile to the west. It is said that a diabase dike passes near the mine.

From the standpoint of the miner the Brewer ore is similar to that of the Haile and Colossus mines. It is a dense blue siliceous ore, carrying finely disseminated pyrite and a variable amount of free gold. The ore of these other mines, however, is a replacement of bedded tuffs, while the Brewer rock is a replacement of what is probably only a massive igneous rock brecciated in place. There is consequently no evidence of bedding nor banding, and the only structure which the deposits show is a number of rather irregular systems of joints. The most prominent jointing strikes about N. 70° E. and dips steeply to the northwest. The Brewer ore is also more siliceous than that from the Haile and Colossus. Although pyrite occurs in the unsilicified rock, it carries very little gold. The pyrite in the blue, silicified rock, which averages about 7 per cent of the total mass,[a] carries, on the other hand, both gold and copper. When the pyrite decomposes it leaves cavities lined with an iridescent film of limonite. A black copper arseno-sulphide, enargite, is also present in small crystals and separates in the gold pan as the so-called "black sand." Where oxidation has taken place, this arsenical sulphide is decomposed and the copper is converted into the sulphate, chalcanthite, which forms a blue coating on the walls in several places, particularly at the north side of the main pit. Covellite has been found in the ore[b] and bismite and native bismuth have been reported.[c] Cassiterite has been found at this mine,[d] sometimes, as reported, in close association with the gold.[e] It seems probable that the cassiterite is an associate of the fluorine mineral of the original rock and that the ore, brought in later, was deposited about this difficultly soluble mineral.

The siliceous cement which binds the silicified fragments into a dense rock has been much attacked by surface water. Along certain planes or lines the cement has been removed by solution, allowing the rock to crumble to a very fine white powder which is almost pure silica. All the sulphur, iron, and copper of the sulphides have been leached out, but the gold remains, doubtless as free gold. Within these soft sandy portions residual masses are often found. They are hard and many of them when broken open are found to have a blue, unaltered core containing pyrite. In numerous instances they assume fantastic nodular forms resembling those of certain concretions. This sandy ore is especially sought for by the miners. In the first place, it is perfectly free milling. Moreover, it is of better value than the average blue unoxidized ore. This difference in value may be partly explained by the fact that the proportion of gold in the sand has been increased by the removal of such material as has been dissolved away. But this seems hardly adequate to account for the marked difference in value which is said to exist. The residual lumps of unoxidized rock found in the midst of the sand are said to be decidedly richer—they certainly hold more pyrite—than rock of similar appearance from the large unoxidized

[a] Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 144.
[b] Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 279.
[c] Tuomey, M., Geology of South Carolina, 1848, p. 97.
[d] Clarke and Chatard, Am. Jour. Sci., 3d ser., vol. 28, 1884, p. 25.
[e] Becker, G. F., op. cit., p. 308.

masses. Apparently this is another instance where descending, decomposing waters have found easiest passage along the same channel which gave to the original ore-bearing solutions their easiest ascent.

In certain places solution has gone on to the extent of forming cavities or vugs in the rock. One of these, encountered in the underground workings at the west side of the main pit, is 3 feet wide, 15 feet long, and 20 feet high. The two greater of these dimensions lie in the plane of a zone of the white sand above described.

The values of the ore mined in the early days can only be inferred from those known more recently; if what seems to be the general rule in this region applies to this particular mine, the first ore was considerably richer than that mined at greater depths. In their report in 1897 Nitze and Wilkens [a] state that the better grade of ore assays $5 to $7 per ton, while the average run of the mine is about $3. As a matter of fact the best ore has all been the decomposed, sandy material, or the residual nodules inside of it, with the one exception of a streak, near the southeast corner of the pit, of very siliceous rock which probably originally corresponded to the portions now decomposed, but which was so thoroughly sealed up by the siliceous cement that surface waters have not been able to penetrate it. At present only the sandy material is being sought for and the mining operations consist in gouging out and following the bodies of this character wherever they may lead. The resulting workings suggest and are indeed closely related in form to the honeycombed structure of much weathered limestone. It is said that under present conditions 60-cent ore can be put through the mill without loss, and $2 is about as good an average as can be obtained. In spite of the selection of the best ore, the grade of the ore is thus evidently decreasing, which probably indicates that the limits of the body from the standpoint of economy are being reached. Nitze's sketch plan of the mine,[b] which shows the unsilicified rock (mapped as granite) closing in on all sides, seems likewise to indicate that the limits of the ore are not far beyond the walls of the present cuts and stopes. It is not improbable, however, that other ore bodies, perhaps connected with the main deposit by comparatively narrow strips of profitable ground, might be discovered by more careful prospecting than has apparently been done. It seems, in fact, that the smaller pit is on such an ore body rather than on the same one as the main pit exposes.

BLACKMON MINE.[c]

The Blackmon mine, situated in Lancaster County, S. C., a little northwest of White Bluff post-office and about 14 miles north of Kershaw, has also been known since the early days of gold mining in this region. It is the property of the Piedmont Mining and Development Company, of Charlotte, N. C., and Mr. O. J. Thies is manager.

Until recently the mine has been idle for many years, although at one time considerable ore was taken out from an open cut.[d] Since the resumption of work all operations have been conducted underground. A shaft started in the hanging wall goes down vertically for 113 feet, where it reaches the foot wall and continues as an incline at about 40° to a point 180 feet from the surface, measured vertically. Drifts and crosscuts, probably amounting in all to 600 feet, have been run at the 80-, 113-, 153-, and 180-foot levels. The surface improvements consist of a 20-stamp simple amalgamation mill and a shaft house, with steam hoist and compressor.

The geology in this vicinity is much obscured by decomposition and by vegetable growth. While the rock relations are fairly plain in the mine, their significance is not so readily grasped. A body of extremely foliated sericite schist which strikes northeasterly and dips 30° to 70° NW. is cut by a porphyritic rock, also somewhat foliated, which lies to the southeast and has followed the planes of foliation of the schist. Both of these are crossed by a dike of diabase which has a northwesterly strike and dips steeply.

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[a] Bull. North Carolina Geol. Survey No. 10, 1897, p. 144.
[b] Nitze and Wilkens, op. cit., p. 146.
[c] Formerly known as Blackman's mine; cf. Tuomey, M., Rept. Geol. and Agr. Survey, South Carolina, 1844, p. 23.
[d] Tuomey, M., Geology of South Carolina, 1848, p. 95.

The schist has always been described as a talc schist, and its appearance certainly warrants such a description; but chemical examination shows that only a slight amount of magnesia is present, and the material is therefore sericite. The rock is more or less soft, decidedly fissile, and varies in color from dull gray to pinkish, bluish, and green. It is made up largely of shreds of sericite or fibrous mica, with a little quartz, numerous tiny red and black garnets, a little magnetite, and a few small fragments with high polarization colors whose identity is unknown. Where cut by the diabase dike the folia are much crumpled. It is probable that this rock is of sedimentary origin. The porphyritic rock, while fairly massive on the whole, is somewhat foliated near the contact with the schist, indicating probably that the intrusion took place just before the cessation of the shearing or folding movements which produced foliation. The contact is not sharp and simple; the schist was probably injected near the main porphyry mass by narrow dikelets of the porphyry, and the subsequent foliation has produced a mingling of the two rocks. In its present somewhat decomposed condition the rock consists of a fine-grained mosaic of quartz, sericite, epidote, and some zoisite, in which are imbedded large phenocrystic grains of quartz and of turbid feldspar, both orthoclase and oligoclase. A little biotite was probably present, but is now decomposed. This rock may be designated a quartz-monzonite porphyry, and is probably closely related to the tuffs which occur at the Haile and Colossus mines. The diabase is doubtless much later than either of the other rocks. Granite is known on the surface about one-fourth mile to the north.

The ore of the Blackmon mine is a zone of sericite schist occurring at the contact with the quartz-monzonite porphyry. Small siliceous lenses between the folia of the schist, averaging one-eighth inch wide and one-half inch long, have been formed, partly by filling and partly by replacement. Where this silicification is most marked the grade of ore is best. A small amount of pyrite accompanies the quartz and may carry gold, but the principal value is as free gold usually in tiny grains or flakes. In this ore zone the schist has a bright, vivid appearance—the colors are striking, ranging from delicate grays and pinks, resembling mother-of-pearl, to beautiful brilliant greens—and the rock is lustrous. Passing into the hanging wall to the more normal rock, the bright colors fade to dull grays and the hardness decreases. Narrow bands of quartz, true veins of filling, occur here and there in the ore body. They carry a little pyrite, but practically no gold. As in the case of all the mines thus far described, these barren quartz veins appear to be of a little later formation than the silicification which produced the ore. Between the ore body and the fairly massive porphyry there is a zone perhaps 5 to 20 feet thick, which forms the foot wall. In appearance it resembles the dull or "dead" schist of the hanging wall, but it is found to pass gradually into the unfoliated porphyry, and the microscope shows that it is of the same composition. It is pretty thoroughly impregnated with small cubes of pyrite, but carries only slight gold values. The density of the schist and the stability of its composition have resulted in excluding surface waters from the greater part of the ore body and the sulphides are in general unoxidized. But along certain fracture planes decomposition has converted the sericite into kaolin, the so-called "talc" of the miners. As a consequence great masses of ore, bounded by and resting on these sheets of soft and exceedingly slippery material, are continually tending to slide in and wreck the workings, and it is only by the strongest timbering that some portions of the workings are maintained. Another serious obstacle to economical mining which arises from the character of the ore is the difficulty of obtaining good results from blasting. The rock is so schistose that drilling can be done practically only at a large angle to the plane of foliation. A water Leyner drill has been put in and in this rock works far better than hand drills or ordinary machine drills. But even when the holes are obtained, it is almost impossible to get the powder to do more than shatter and loosen great slabs of the schist, which are still left wedged in place almost as firmly as before. Time and experience may disclose some more efficient manner of placing or loading the holes than has yet been discovered.

The ore body is a zone of altered schist parallel to the dip and strike of the schist of the region and to the contact with the quartz-monzonite porphyry. Measured horizontally,

the mass that can be considered ore has an average width of 35 feet; it has been opened along the strike for 300 feet and may extend farther to the northeast. To the southwest it reaches practically to the diabase dike, but not beyond it, so far as present explorations have shown. As mined across this width the ore will average about $2 per ton. A richer streak occurs not far from the foot wall; it is usually green in color and is more siliceous than most of the ore, a fracture face across the foliation showing small siliceous lenses enmeshed in the sericite matrix. In this rich streak, about 25 feet northeast of the dike on the 113-foot level, a bunch of $35 ore was found. The values gradually decrease toward both foot and hanging walls. While the change from pay ore to unprofitable rock is not sharp and distinct, it is fairly abrupt, and there is little difficulty in recognizing the approximate line where pay values cease. The size and richness of the ore body appear to be holding out well with depth, and if the difficulties experienced in breaking and holding the ground can be overcome and the values can be successfully recovered by amalgamation, as seems thus far to have been the case, there is reason to expect that the future of this little mine should be bright. But developments are not yet sufficiently extensive to warrant any very far-reaching prognostications.

Apparently the ore-bearing solutions which produced this deposit were intimately related to the quartz-monzonite porphyry and closely followed the intrusion of that rock. Another peculiarity of this deposit which distinguishes it from those already described is that the gold occurs principally native, the pyrite carrying very little value. While this deposit can be regarded only as a replacement of the schist, in a way it approaches rather closely to the group which have been formed by the filling of fissures, and with the Ferguson mine, described on pages 96–99, constitutes a close bond between the replacement deposits and the vein deposits.

KINGS MOUNTAIN MINE.

This celebrated mine, first known as the Briggs[a] mine, and more recently as the Catawba[b] mine, is situated in Gaston County, N. C., near the western foot of Kings Mountain and about 2 miles south of Kings Mountain station. It has not been in operation for a number of years and was filled with water and inaccessible when visited by the writer. The following description is based mainly on the observations of others.

The mine was discovered in 1834[c] and was successfully worked for several years by the discoverer, Mr. Briggs.[d] Later Commodore Stockton, who seems to have been a moving spirit in the gold-mining industry of this region, operated the mine for a number of years. Work was necessarily stopped during the war, but two or three years after its close a 20-stamp mill of the California type was built.[e] It is worthy of note that this was practically the first adaptation of western practice to the ores of the East.[f] Work continued at intervals up to 1895, since which time nothing has been done. It is said that the property is now involved in litigation among persons in Richmond, Va.

As is the case with nearly all the southern mines, no actual records of production have been kept. Kerr in 1875[g] stated that the production had been over a million, while Professor Hanna, who has been for many years in charge of the United States assay office at Charlotte, N. C., and who is probably best able to judge of the output of the Carolina mines, estimates the production of the Kings Mountain mine at $750,000 to $900,000.[h]

The amount of development can only be inferred from the incomplete descriptions of former writers. There are at least six shafts on the property. The two principal ones are the Holliday shaft, 330 feet deep, and the Rock or pump shaft, about 120 feet to the southwest, also 330 feet deep. All the shafts are vertical and are sunk in the hanging wall of the deposit. The main workings center about the Rock shaft. Crosscuts to the vein and

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[a] Lieber, op. cit., vol. 1, p. 92.
[b] Kerr and Hanna, Rept. North Carolina Geol. Survey, vol. 2, 1888, p. 304.
[c] Nitze and Hanna, Bull. North Carolina Geol. Survey No. 3, 1896, p. 147.
[d] Lieber, op. cit., vol. 1, p. 92.
[e] Kerr, W. C., Rept. Geol. Survey North Carolina, vol. 1, 1875, p. 280.
[f] Cf. Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 35.
[g] Loc. cit.
[h] Nitze and Hanna, Bull. North Carolina Geol. Survey No. 3, 1896, p. 147. Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 309.

levels on the vein have been run from the Rock shaft at a depth of 140 feet, mostly to the southwest, and from the 270-foot and 330-foot levels to the northeast to connect with the Holliday shaft. There are two shallower shafts farther northeast and two southwest of these workings. A large amount of stoping has been done on each side of the Rock shaft. Considerable decomposed rock from the outcrop of this deposit southwest of the Rock shaft has been removed and washed in rockers. Besides a shaft house, hoist, steam pump, and Cornish pump at the Rock shaft, there is a substantial 30-stamp mill with concentrating tables.

The geology is not well shown by surface exposures. As this mine is situated on the slope of the Kings Mountain Range, the rocks all strike to the northeast, and at this place the dip is northwest. A somewhat micaceous schist incloses an interstratified bed of limestone. The limestone is impure and schistose and is often closely interbanded with the biotite schist. The limestone is shot through with interlaminated stringers of quartz and is somewhat silicified and pyritized, especially along the planes of most intense foliation. A zone of impure graphite, in many places heavily impregnated with coarse-grained pyrite, underlies the limestone. Southwest of the Rock shaft the ground is strewn with lumps of iron oxide, probably derived from the decomposition of pyrite. Some of this iron is naturally magnetic. There are indications of a small lateral fault south of the Rock shaft, by which the northeast side of the vein is thrown 10 to 12 feet to the southeast. It has been said that a granitic dike was encountered in the workings.[a] This might be a dike of pegmatite, which occurs abundantly a mile or so to the northwest.

The richest ore of the Kings Mountain mine is contained in the narrow veins or stringers of quartz bearing gold and auriferous pyrite. These seem to have been rather more abundant in the upper portion of the mine than at the depth where the last work was done. The inclosing schistose limestone, however, has been sufficiently penetrated by the solutions which circulated in the veins to have deposited in it as impregnations enough gold and pyrite to make it an ore. In the upper decomposed portion, which is stained by the oxidation of the iron sulphides and called "brown ore," the gold occurred free, and so long as amalgamation was the only recovery process employed, this ore was eagerly sought for. There is no doubt, however, that this oxidized ore was really richer than the corresponding unchanged ore below. The quartz stringers were so charged with pyrite that when that mineral oxidized they were honeycombed and crumbled almost as easily as the softer decomposed schists, and thus the whole outcrop could be easily worked in rockers. It was only when development penetrated fresher rock that the presence of limestone was discovered. Whether the appearance of limestone at some depth is to be attributed to the fact that it is a lens-like body, not reaching to the surface, or that it was sufficiently impure to furnish, on oxidation and solution, the residual material occurring near the surface, it is impossible to decide, but the latter seems the more reasonable conclusion. Alternating bands of limestone and schist, when carrying workable values, were known as "calico ore." Both in the quartz and the impregnated limestone other minerals were present in addition to pyrite. Pyrrhotite, chalcopyrite, galena, and zinc blende were not uncommon, and among the rarer ore minerals were mispickel, tetrahedrite, nagyagite, altaite, and bismite; and besides the calcite and graphite of the limestone were the gangue minerals—quartz, sericite, and fluorite. The mineralogical character is thus seen to have been pretty complex. Whether the ore-bearing solutions differed correspondingly from that type of solution which seems to have formed most of the other gold deposits of the region, or whether the difference lies in the greater chemical instability of the limestone, it is impossible to determine. The fact that arsenic, antimony, and tellurium have not been found in the other mines described would lead to the conclusion that the solutions were of different character, while the presence of bismuth compounds at the Brewer mine and of fluorite at the Schlegelmilch and the general character of the Kings Mountain deposit, make it easy to believe that the two classes of deposits are intimately related in origin. Chalcanthite, which is present as a coating on the stope walls, has doubtless been derived from oxidation of the

[a] Becker, G. F., op. cit., p. 309.

chalcopyrite, and needles of epidote, found in some of the decomposed porous ore are perhaps likewise of secondary origin.

This ore has a rather wide range of values, assays showing from a trace up to over $75 per ton.[a] It is said that the ore as mined averaged perhaps $4 to $6 per ton.[a] Of this, not over $3 was saved,[b] largely, it is said, because the graphitic material of portions of the ore prevented the amalgamation of much of the fine gold. The concentrates ran $35 to $40 per ton. The amount of silver in the ore was very small, but was approximately proportional to the amount of gold.

The ore body consisted at the surface of the siliceous iron gossan, and in depth of the impregnated schistose limestone and the quartz stringers in it. It was parallel to the foliation of the rocks, striking about N. 40° E. and dipping 45° to 55° NW. This body reached in places a width of 60 feet. It consisted in reality of five known shoots of richer ore, especially penetrated by gold-bearing quartz stringers, and generally near the graphite foot wall, together with the poorer material which occurred between and along the walls of these shoots. It is said that a stope begins near the surface at one of the old rocker pits, 200 feet southwest of the Holliday shaft, extends beyond that shaft, probably 400 feet in all, and gradually deepens to the northwest till at the Holliday shaft it is 330 feet from the surface. The writer was told by Mr. R. Hufstickler, one of the former miners, that some of the best ore in the mine was left in the bottom of a 30-foot winze below the bottom level when work was last stopped. Beyond this meager statement nothing can be said as to the possible extent of this ore body or the future of the mine.

FERGUSON MINE.

The Ferguson mine is situated in the northwest corner of York County, S. C., about 7 miles by road northeast of Kings Creek station, on the Three C's branch of the Southern Railway, and about 11 miles southeast of Grover, N. C., on the main line of the Southern. It is owned by Messrs. Frank & Dover, who are operating it at the present time.[c]

This mine has been known for some time and was worked some years ago by Maj. John F. Jones, of Blacksburg, who is said to have hauled 1,500 tons of the ore to that place for treatment. Recently it has been taken up by the present owners. In addition to four old incline shafts sunk on the vein, that to the southwest being the deepest (80 feet), a new vertical shaft 100 feet deep has been sunk in the hanging wall and a crosscut run 60 feet to the vein, on which stoping is being done in a small way, really as exploration or development work. The surface improvements include a stamp mill (five stamps in place and foundation ready for five additional) with Wilfley table, and a cyanide plant, besides head frame and hoisting engine at the shaft.

The geologic relations were only partially grasped in the short time spent at the mine, and it required microscopic study of the specimens collected to reach the opinions now held. The Ferguson vein lies approximately at the contact between amphibolite and a porphyritic tuff, both of which have been subjected to much foliation. The amphibolite, which lies on the southeast, is a rather massive dark rock, which at close view is seen flecked all through with small light-colored particles. Toward the contact, which strikes about N. 40° E. and dips 65° to 75° SE., the foliation is more marked and the rock becomes slaty. The lack of sharpness at the contact with the porphyritic tuff may be an indication that the amphibolite has been derived from a rock which was also tuffaceous or brecciated, but certain remains of igneous-rock structure make it probable that the original rock was a diorite or gabbro. The tuff, which occurs on the northwest side of the contact and outcrops in the stream some distance west of the mine, is of gray color with a silvery luster, and has a decided fissility or schistosity which may correspond to original bedding of the tuff. The fresh and glistening rock from underground is called, as at other mines, "fish-scale slate." The mineral fragments which make up this rock show that the massive equivalent would be a quartz-monzonite porphyry. It is practically identical with the tuff at the Colossus mine and probably the same as that at the Haile. There seems to have been a zone of especially

[a] Nitze and Hanna, Bull. North Carolina Geol. Survey No. 3, 1896, p. 147.
[b] Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 67.
[c] According to report, this mine was closed down in 1905.

marked foliation at the contact of the two rocks or just within the amphibolite. The result is a band of exceedingly schistose rock of light-green color and lustrous surface, composed very largely of sericite but containing also quartz and epidote. It seems probable that this product is the outcome not only of the shearing but of the action of the vein solutions. This zone outcrops noticeably on the surface southwest of the shaft and is reached underground at the bottom of the shaft.

The Ferguson ore deposit lies principally in the porphyritic tuff. It would at first be taken as a representative of the fissure-vein type, and so it is; but it is more than that. By the deposition of quartz as a filling of space it represents the fissure veins and by the impregna-

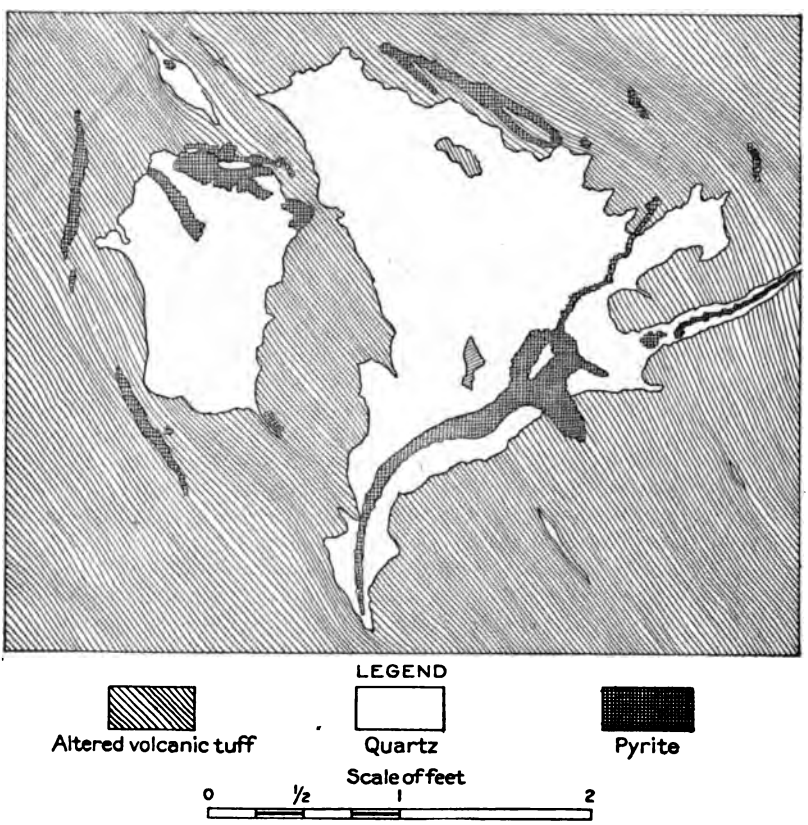

FIG. 11.—Sketch of vein, vertical section, Ferguson mine, winze, looking northeast.

tion of the fissure walls by the ore-bearing solutions it stands as a close link to the replacement deposits. In fact, if the quartz lenses could be completely removed, there would remain a small and low-grade replacement deposit, similar in character to those of the Haile and Colossus mines. The ore is thus of two kinds—vein quartz carrying good values and adjoining wall rock (cf. pp. 59–61) carrying just about enough gold to pay for milling what is broken rather than sorting it out. The quartz ore from the vein carries only a slight amount of free gold where it is unoxidized;[a] but the proportion of pyrite is rather large, averaging about 10 per cent. The pyrite occurs plentifully within the quartz, but shows a marked tendency to segregate near the vein walls and in many cases it occurs in the wall rock just outside the quartz. Fig. 11 is a sketch of one side of the winze which is being sunk

[a] Mr. Frank informed the writer that he had never seen a particle of native gold in the undecomposed ore from this mine. Amalgamation tests have yielded $1 per ton.

from the 100-foot level. The quartz body represented continues upward toward the observer and downward away from the observer; like nearly all the quartz lenses, it has a pitch to the northeast in the vein. The irregularities shown in the figure indicate that replacement has gone on. Besides the pyrite which can be shown in the sketch, minute crystals are scattered through the wall rock and doubtless contribute to it a small amount of gold. The tuff is silicified, too, as in the other replacement deposits. Filling is indicated, on the other hand, by the fact that some of the solid bodies of quartz include fragments of the wall rock with foliation not corresponding to that of the walls in place. Moreover, in the roof of the crosscut from the shaft, just where it reaches the vein, the quartz adjoins amphibolite instead of tuff. Here the pyrite is mainly contained in the quartz; the contact between quartz and amphibolite is sharp and is defined by a narrow band of black biotite scales which separate the two and which have doubtless been formed from the amphibolite by the action of the vein solutions. Under the microscope this biotite possesses the clear chestnut-brown color characteristic of contact-metamorphic biotite. Here and there the vein quartz contains little flakes or tufts of sericite, which have the appearance of being contemporaneous with the quartz, but the evidence is not certain. A few tiny flat crystals of black ilmenite occur in the quartz. This strengthens the relation between the gold-quartz veins and those ilmenite-bearing quartz veins which are not known to be auriferous. (See pp. 64–65.) Numerous crystalline grains of apatite in the replacement portion of the deposits emphasize the similarity to the Haile mine and suggest relation to the Dahlonega deposits, where apatite occurs in the veins (p. 124). Where the vein cuts amphibolite, the original magnetite (or ilmenite?) of the rock is in many instances partly or completely replaced by pyrite, and in a few cases magnetite has been deposited on the pyrite. In the amphibolite near the vein are scattered small bunches of crystalline calcite, surrounded by dark-green specular or micaceous chlorite, heavily impregnated by pyrite; this is undoubtedly a product of the vein solutions.

The pyrite-bearing quartz ore from the vein averages $10 to $15 per ton. The replaced wall rock, impregnated by silica and pyrite, averages about $3. The amphibolite wall rock is said to average $1.50 per ton and the sheared sericite zone in the amphibolite $2. The concentrates average $100 and perfectly clean pyrite $150 to $175 per ton.

So little of the gold is free that amalgamation is not practiced. The pulp, stamped to 15-mesh, is run direct to the Wilfley table. The headings are stored, in the prospect of being either shipped or roasted and cyanided on the ground. The tailings are run to a pneumatic-cone separator, where the slimes, averaging 15 per cent of the tailings and running $20 per ton, are taken out and cyanided during mechanical agitation, while the sands, carrying $6 to $7 in gold, are treated with strong cyanide solution without agitation. It is understood that the process is not yet wholly satisfactory. Possibly more careful crushing to avoid sliming, more efficient concentration and classification, and then roasting of all the headings and subsequent lixiviation might give a better extraction at perhaps no greater cost.

The ore bodies of the Ferguson mine, like the other fissure-vein deposits, are influenced in their form by the structure of the surrounding rocks. In this case their form has been further modified by the effects of replacement. The result is rudely lenticular masses of quartz surrounded by low-grade zones of replaced wall rock. Four of these lenses are known and have been worked to some extent by separate shafts. Only one, the northeasternmost, is now being explored. Present work is being carried on as the downward continuation of a former stope. On the 100-foot level this stope is 4 to 8 feet wide and 25 to 35 feet long. It reaches upward to the surface and has been explored 30 feet below the level by an inclined winze sunk on the pitch of the shoot, which is steep to the northeast. This work is being carried on solely with the idea of exploration, but in the hope that by following the ore it will pay for itself. The winze will be carried down to the 200-foot point if the ore continues, in which event the shaft will be sunk another 100 feet and connected with the vein. If the present dip of the vein continues, the shaft should cut the vein at approximately 300 feet.

If the pitch of the other ore shoots likewise persists, they should all be within easy striking distance of the shaft at that depth. The plan therefore is to explore this northeastern ore shoot to the 300-foot level and, if it proves satisfactory, to tap the other shoots, in the hope that they are similar to the first. The policy here adopted of exploring by *following the ore*, rather than by sinking and crosscutting in the hope of striking it, is to be heartily recommended in this region of irregular and nonpersistent deposits. The foresight with which the shaft has been located and future work planned is a gratifying exception to the way in which most of the gold-mining enterprises of the South have been started.

The structural and other outward features of this deposit strongly resemble those at many of the mines in the greenstone schists of central Ontario, where quartz veins carry auriferous pyrite.

Some specimens of vein quartz from a deposit about one-half mile to the southeast of the Ferguson shaft—probably what is known as the Ophir mine—contained free gold not derived from the decomposition of pyrite, although some pyrite was present. Some of this ore is said to be very rich. Two hundred tons have been hauled to the Ferguson mill. About 300 tons shipped to the smelter at Norfolk, Va., are said to have given returns of $25 per ton.

BROWN MINE.

This mine, situated in York County, S. C., about 4 miles south of Hickory Grove station on the Southern Railway, is owned by Mr. W. E. C. Eustis, of Boston. It was once worked by Mr. Fred Frank, now part owner of the Ferguson mine, who took out some good ore and made some money out of it. The production is not known—probably a few thousand. Three shafts and their workings and a crosscut tunnel, aggregating something like 1,500 feet of exploration work, comprised the development before the present owner took control. Since then an 80-foot inclined shaft has been sunk. Work was abandoned in 1905, after a small amount of ore had been taken out.

The country rock was probably an amphibolite, but the only obtainable specimens which had not been affected by weathering were so near the vein that they had suffered marked alteration by the vein solutions. The rock thus produced is dark gray, somewhat foliated, and resembles many granitic gneisses. It is composed of abundant feldspar, mostly microcline and albite; plentiful small flakes of biotite of the contact-metamorphic variety; numerous grains of epidote and almost as much zoisite, in short, stout crystals; and occasional grains of titanite. Lenticular aggregates of quartz, numerous grains of pyrite, and sparing pyrrhotite have probably been deposited by the vein solutions.

The vein, which strikes approximately N. 45° E. and dips about 70° NW., is parallel to the foliation of the amphibolite country rock. Its dip is not constant, flattening somewhat at about 30 feet, then steepening again at a depth of 70 to 75 feet.

With the exception of disintegration, resulting from decomposition of the vein and the surrounding rock, the vein is well defined near the surface, being a solid mass of pyritiferous quartz about 3 feet wide. In one place, however, near the old Frank incline, a lateral offset or jog of about 12 feet occurs, both at the outcrop and underground. The description of this occurrence underground is interesting as throwing light on the structure of these interfoliated veins in schist. On the surface the vein is continuous but crooked (see *A*, fig. 12), while underground at the 80-foot level the vein breaks up, probably somewhat as shown in *B*, fig. 12. These sketches are based on description of the behavior of the vein, supplemented by what was visible on the surface at the time the mine was visited and on assumptions drawn from occurrences at other portions of the vein. The influence of jointing has certainly been marked. *A* and *B*, fig. 13, represent what might possibly be the case at depths of 200 and 300 feet, respectively. This series, hypothetical with the exception of *A*, fig. 12, is intended to represent the variations in structure which may take place in a vein in a comparatively short distance. It also shows how such apparently disconnected lenses as occur in the Schlegelmilch mine (fig. 14) are in reality all connected, and it emphasizes the advisability of following stringers or offshoots if the main vein gives signs of pinching out.

There is evidence in other parts of the workings of the vein having pinched and offset, as in *A*, fig. 12. A crosscut tunnel from the northwest passes, at a depth of 60 feet, the point where the vein ought to be, without cutting anything but stringers, although the vein occurs with normal width on each side of this place on the surface. It is probable that this gap is

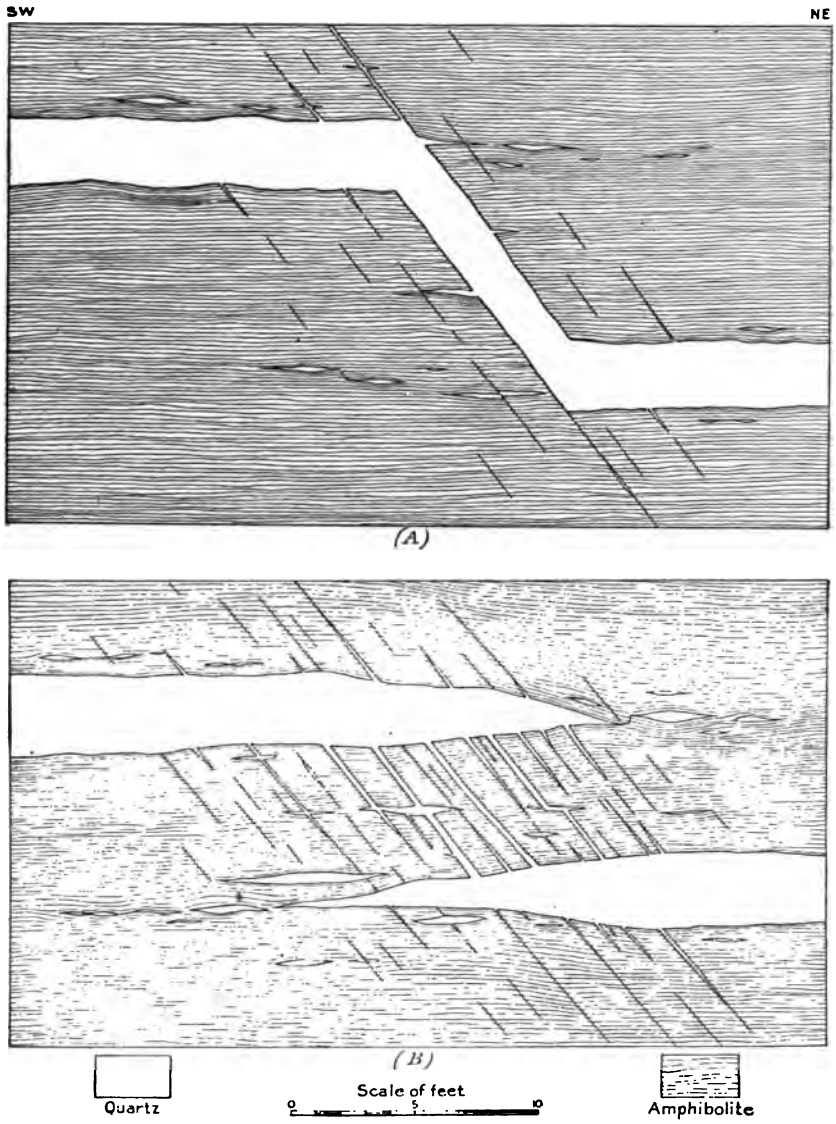

FIG. 12.—Diagrammatic sketch plan of vein at Brown mine. *A*, Vein at surface, showing offset due to presence of one predominant joint plane; practically no faulting. *B*, Vein at depth of 80 feet, showing pinching along one plane of foliation and continuation along another; also influence of numerous coordinate joints in leading the solutions from one main fracture to the other.

horizontal rather than vertical, for it corresponds in position to a gap encountered in the new incline a short distance to the southwest. In sinking this new shaft the vein was followed downward at 55° to a depth of about 55 feet, where it pinched out. It had been noticed that little joint planes or crevices branched off into the foot wall, so the shaft was steepened;

soon a narrow stringer dipping about 70° was picked up and followed. This stringer widened, and in a few feet had attained the proportions of the main vein. At 80 feet another irregularity occurred, and work was stopped at that point without determining the nature of the difficulty. A few feet southwest of the new incline the vein gives out. The miners believe that faulting has taken place, and such may be the case, but it may be that pinching alone is the cause, in which case a small amount of surface trenching ought to expose the continuation of the vein.

The ore at this mine is confined wholly to the fissure filling. The massive quartz contains pyrite—in some places a large proportion—of various degrees of perfection of crystal form. The sulphide carries the great portion of the gold. One peculiarity of the decomposition of the pyrite at this mine is the formation of crystalline sulphur (see p. 64). The ore as broken runs $4 to $7 per ton, although some heavy sulphide portions have been much richer. Sorting raises the average value to about $12, the quartz without pyrite always being rejected. Considerable stoping was done by Mr. Frank. He took out most of the vein from the 50-foot level and in places from the 80-foot level to the surface for a distance of probably 300 feet along the strike. A few hundred tons have been taken out along the new incline by the Eustis management.

The comparatively low grade of the ore, irregularity of the vein, and the combat with water will always make the working of this mine expensive.

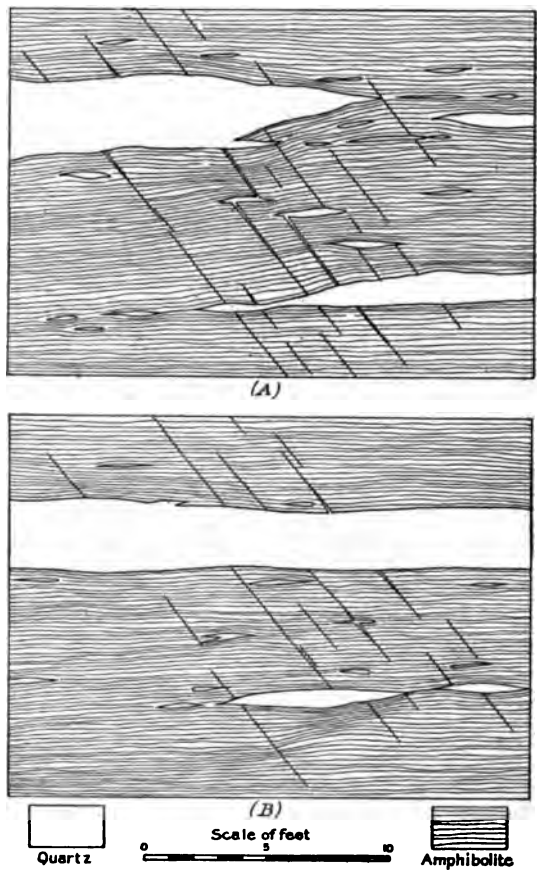

FIG. 13.—Hypothetical plan of vein at Brown mine as it might appear at greater depths. *A*, Vein as it might appear at some distance below the 80-foot level, showing pinching and the slight influence of joints. *B*, Vein as it might appear at some still greater depth, showing the vein again continuous by the uniting of so-called lenses.

SCHLEGELMILCH MINE.

In western York County about 3 miles southwest of Hickory Grove and about 1½ miles northwest of the Brown mine, is the Schlegelmilch mine, which is also the property of Mr. W. E. C. Eustis. This mine was worked over fifty years ago by the first owner, from whom it is named. No idea of the production can be given. It is known simply that some oxidized ore of good grade was taken out in the early days. The amount must have been small. Besides several old shafts extending down to water level, or down to the limit of general oxidation—perhaps 40 to 50 feet—which are in most cases caved in, a shaft about 100 feet deep has more recently been sunk and probably 250 feet of drifting done. A small steam hoist was in use. The Schlegelmilch mine was closed down at the same time as the Brown and is not now in operation.

The country rock for miles around, so far as known, is amphibolite, of varying degree of foliation but all sufficiently squeezed to be classed as schist. Several quartz veins occur in the amphibolite parallel to its foliation, which here strikes about N. 35° E. and dips about 65° SE. Although some work was formerly done on at least three of these veins, only the southeastern one is now being worked. On and near the surface the vein is fairly regular, averaging about 2 feet wide. At about 70 feet the vein pinches and soon splits up as represented in fig. 14, which is a sketch of the cross section of the vein as shown at the northeast end of the shaft at the 85-foot level. These lenses have been somewhat modified in form and outline by subsequent crushing, so that the exposure at the side of the shaft suggests magnified augen gneiss.

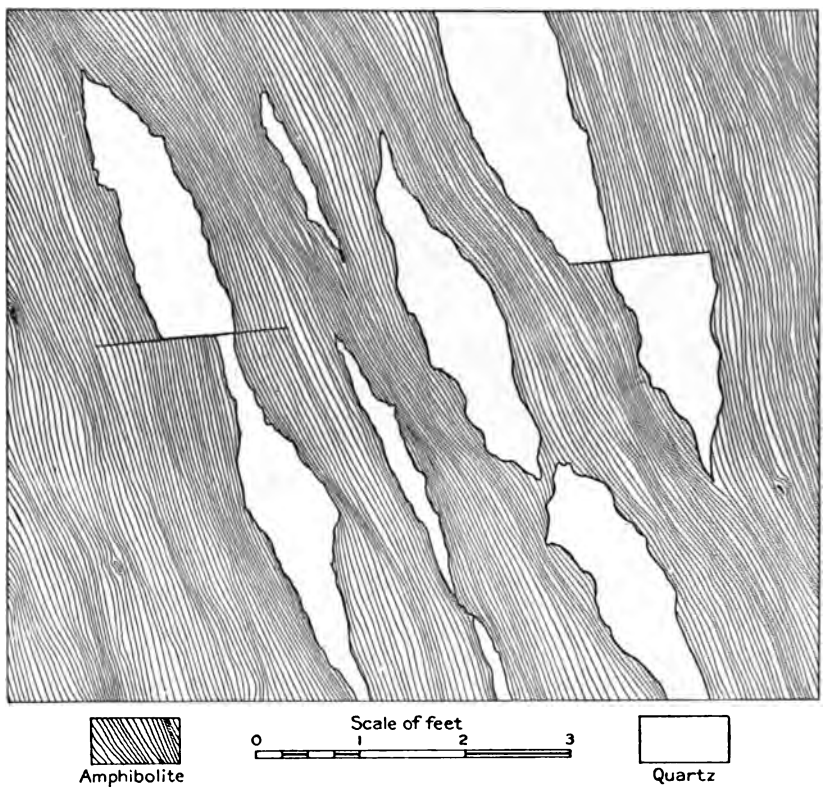

FIG. 14.—Sketch of vein, vertical section, Schlegelmilch mine, near bottom of shaft, looking northeast.

The vein stuff is quartz carrying a variable proportion of auriferous pyrite, which, in some cases at least, is slightly cupriferous. So far as known native gold does not occur in the unoxidized portions of the vein. Pyrite, sericite, calcite, biotite, chlorite, and perhaps serpentine are developed in the near-by amphibolite by the metasomatic action of the vein solutions. Pyrite is not abundant in the wall rock and occurs usually as small cubes. The calcite, because of its easy solubility, is frequently found in crevices in the quartz vein, having probably been carried in from the walls. Much of it is slightly greenish, perhaps because of a slight intermixture of chlorite. A narrow veinlet of fluorite cutting the quartz is obviously of later formation, but is doubtless referable to the same source as the siliceous solutions. Assays of specimens from neighboring portions of the vein show decided fluctuations from almost nothing to $50 or over per ton. The average value was not learned

No stoping nor drifting has been done below the 45-foot level, but from that level upward the ore has been about all extracted for 50 feet northeast and perhaps 150 feet southwest of the shaft. At least half of that stope, however, was made years ago. Since the writer's visit the shaft has been carried to a depth of 100 feet, where the vein is said to have pinched out entirely. Crosscuts were run in both directions, and while it is not known how carefully this exploration was carried on and to what extent the influence of the wall-rock structure was studied and considered in directing this work, the continuation of the vein was not discovered.

THOMPSON MINE.

The Thompson mine lies in the western part of Union County, S. C., about a mile northeast of West Springs post-office and about 3 miles east of Glen Springs, Spartanburg County, the terminus of a branch of the Charleston and Western Carolina Railway. The mine is the property of the Ophir Gold Mining Company, of Indianapolis, Ind., and is being worked under lease by Mr. M. C. Mayes. At the time of visit the mine was partially filled with water and thus inaccessible. Only meager information could be gleaned from an examination of the dumps and old cuts and from a study of specimens found there. What is here recorded has been obtained largely from the writings of others.

As early as 1847 this was one of the well-known mines of the State.[a] It is doubtless the same as that described by Tuomey[b] in 1844 as the Fair Forest mine. Work was continued in the fifties and perhaps until the beginning of the war. Little information can be obtained of more recent work, except that in the nineties Mr. O. J. Thies, now manager of the Blackmon mine, directed operations for a short time. Some hydraulicking, with attendant milling of the coarse material according to the so-called Dahlonega method, was done in 1895.[c] The production may have been considerable—perhaps $100,000 or more. The only statement in print is that $6,000 was taken from one shoot in 1847.[d]

The workings consist of a vertical shaft 165 feet deep and an incline reaching to about the same depth, connected by drifts and crosscuts. An open cut over 100 feet long represents the work done in early days and the recent hydraulicking. A 20-stamp mill with two Wilfley concentrators is connected with the workings by a tramway.

Two varieties of rock occur here. The one which is more widely exposed is a biotite schist of brown color and marked fissility. Feldspar is present as small grains with an albite core and labradorite interior. A little magnetite is present. The origin of this rock is unknown. The other rock is an amphibolite which is said to occur as a dike-like band in the biotite schist. Only one contact was seen and at this place the foliation of the two rocks is parallel, and in a tunnel which starts near the mill this mass of amphibolite seems to be fairly wide. The foliation of both rocks strikes about N. 10° E. and dips to the west something like 70°. The mica schist is the ore-bearing rock. No very good idea of the veins could be had, but it is certain that very quartzose zones parallel to the foliation of the rock have been the richest portions. Small quartz stringers seen in the decomposed upper portions of the deposit indicate that filling of fissures has gone on.[e] On the other hand, specimens of quartz-pyrite ore, carrying gold, from greater depth indicate that extreme silicification of the mica schist has taken place along certain narrow zones. This ore is composed principally of white quartz grains, with scattered interstitial flakes of biotite, muscovite, or chlorite. Pyrite is abundant in places. The actual contact of this mass with the schist, which would probably have decided whether replacement had or had not gone on, was not seen, but schist from near the "vein" or ore-bearing zone shows the effects of vein metamorphism; sharply defined plates of muscovite have been developed at the expense of the biotite, pyrite has been introduced, and well-crystallized prisms of a mineral of unknown

[a] Lieber, op. cit., vol. 2, 1857, p. 70.
[b] Rept. Geol. and Agr. Survey South Carolina, 1844, p. 24; also Geology of South Carolina, 1848, p. 91.
[c] Nitze and Wilkens, Bull. N. C. Geol. Survey No. 10, 1897, p. 77.
[d] Lieber, op. cit., vol. 2, 1857, p. 70.
[e] Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, p. 309.

identity but similar in some respects to epidote pierce both the schist and quartz lenses which have developed in it. The most probable conclusion is that intense replacement or metasomatism has gone on in the mica schist along narrow but easy fracture channels for siliceous sulphide solutions. On this ground, therefore, this deposit would also in a way stand between the replacement bodies of the Haile, Colossus, and other mines and the fissure veins like those at the Brown and Schlegelmilch mines, but it holds a different kind of intermediate position from that of the Ferguson deposit.

The ore consists of the granular white quartz with disseminated auriferous pyrite and free gold. Some very rich specimens were seen, in which the gold was scattered all through the quartz much as particles of magnetite might occur in quartz sand. This sort of ore has been found mostly near the surface, and the fact that at greater depth grains of pyrite play the same rôle as the gold above makes it probable that the gold has been liberated by oxidation of the sulphide. It is worthy of mention, however, that the quartz-bearing free gold is, in many cases, at least, wholly unstained by iron as would be expected where oxidation of pyrite had taken place. The concentrates are of good grade, having a shipping value of over $100 per ton, and this is another argument in favor of oxidation of the portion where the gold is now free. Moreover it is said that in general the heavier the pyritization, the higher the value of the ore. Of the unoxidized ore it is not known how much gold is recovered by amalgamation.

As nearly as could be learned, an ore shoot about 90 feet long has been followed from the surface down to the 165-foot level, where work is now being done whenever the water can be kept down. Another bunch of ore 200 feet to the north was worked in former days to a depth of probably something like 100 feet, but the shaft and workings are now caved in. The ore varies in width from a foot to 8 feet or more.

No information was obtained which throws light on the question of persistency of the ore body. The average value of the ore is not known to the writer, but is probably rather good.

OTHER MINES.

Mining for gold has been carried on in many other portions of the area included in this report. At most of these operations were abandoned so long ago—in many cases before the war—that their names were barely more than a memory in the minds of those interested in this subject; in fact, the existence of several mines has been learned only from old literature on the geology of this region. Many such were of course not visited at all. Brief mention is made of some of these, based on hearsay or on earlier writings. Some other mines or prospects were visited, but these were mostly inaccessible and but little could be learned, while a number of the places visited never deserved more consideration than the small amount of prospecting which was given them before they were abandoned.

West mine.—The West mine is in Union County, S. C., only a few hundred yards southeast of the Thompson mine. The two were probably discovered at about the same time and have always been treated together in descriptions. At the time of the writer's visit the workings were filled with water and the old stamp mill was in a sad state of dilapidation. One man was washing in a small stream near the mine gravels which had been subjected to the same operation many times before. As his labor was resulting in small profit and as he was unacquainted with the history of the underground workings of the mine, little information was elicited from him.

In 1844 a shaft had been sunk to a depth of 115 feet and was said to be the deepest shaft in the State.[a] In 1857 this shaft had been deepened to 150 feet,[b] and is now said to have a depth of 175 feet. An old, open cut, mostly filled with water, shows that the trend of the country rock is parallel to that at the Thompson mine (N. 10° E.) and that the ore is similar in character. It is said that some of the ore was of high grade, but that a large proportion of the value was lost because the sulphides were not saved.

[a] Lieber, op. cit., vol. 2, p. 70.
[b] Tuomey, M., Rept. Geol. and Agr. Survey South Carolina, 1844, p. 24.

Nott mine.—This mine is located in Union County, S. C., about 2 miles north of the Thompson mine. It must have been worked during about the earliest days of gold mining in the South and was one of the prominent mines of the time.[a] Portions of the deposit were very rich, $3,000 having been taken from something like half a ton found in one pocket.[b] The country rock is amphibolite, some of it evenly fine grained, some coarser and banded. The vein, which is said to have had a strike of about N. 75° E., was about 8 feet wide on the surface and 5 feet at the bottom of the workings (110 feet), but reached a maximum width of 14 feet at 30 feet from the surface.[c] It is said that the vein split toward the east, that portion which continued along the strike being barren, while the branch which bore off more to the northeast carried the values.[d] Since this statement was not based on the personal observation of Doctor Lieber, its authenticity may be questioned, inasmuch as such splitting is not known elsewhere in the region.

The quartz vein carries considerable pyrite, which doubtless contains most of the gold. It was a bunch of decomposed pyrite that gave the $3,000 mentioned above. The pyrite is also cupriferous, as shown by iridescent films on the slightly weathered sulphides and greenish stains where more oxidation has gone on. It is said that thin scales of metallic copper were found near the water level, probably indicating that some secondary enrichment has taken place.

Magnolia mine.[e]—This mine, located in western York County, S. C., about 3 miles southwest of Hickory Grove, is the property of the Magnolia Mines Company, of Memphis, Tenn. It was worked before the war, under the name of the Louise mine, to a depth of 30 to 40 feet, or as deep as complete oxidation extended, and is said to have been profitable, but no idea of the total production could be had. The oxidized ore was treated in a stamp mill in which the mortar and stems were of wood, and the iron shoes struck upon cast-iron bottom plates instead of dies. The present mill, erected a few years ago, is the fourth mill which has been built on the property. It has three stamps of 1,250 pounds each, and discharges on all four sides. Screens of 80 mesh were first used, but were exchanged for 20 mesh. One Wilfley and one Standard table are installed. No work is being done at present in mine or mill.

The country rock is amphibolite, much decomposed at the surface. Numerous quartz veins, parallel to the foliation of this rock, strike N. 35° to 40° E. and dip about 75° NW. There are two groups of these veins; one situated near the mill, close to Guionmoore Creek, may be called the Magnolia group, and consists of the Magnolia, Gertie, Spring, Sea Crest, and at least two other veins; of the other group, about a mile northwest of the mill, only the Dorothy vein has been worked, although other veins are present. This Dorothy group is the northeastern continuation of the veins of the adjoining Schlegelmilch property. The Dorothy vein is probably the same as one which was worked in the early days just to the northwest of the present Schlegelmilch shaft. Of the Magnolia group, the Magnolia and Gertie veins are most important, although some good ore was taken from shallow workings on a vein a little to the southeast of these. A shaft 110 feet on the Gertie vein and an adit striking the shaft at 75 feet are now caved. This adit, called the Rock drift, is said to be about 1,100 feet long, but left the vein soon after passing northeast of the shaft and became in reality a crosscut tunnel. Several veins are said to have been encountered, but were not worked. The Magnolia vein, a short distance to the southeast, is opened by a 150-foot adit tunnel, which gains only 30 or 40 feet of depth in that distance. This tunnel is partly caved, but allows a view of the vein, which is 2 to 2½ feet wide, contains considerable partially oxidized pyrite, and has the appearance of good ore. Stoping has been carried to the surface for nearly the full length of the tunnel. A shaft about 40 feet deep close to the Magnolia vein is said to cut both it and the Gertie vein by a northwest crosscut from the bottom. The partially oxidized ore which is here encountered in the Magnolia vein is said to assay

[a] Lieber, op. cit., vol. 2, p. 64.
[b] Tuomey, M., Geology of South Carolina, 1848, p. 92.
[c] Lieber, op. cit., vol. 2, p. 66.
[d] Idem, p. 65.
[e] Perhaps the Smith mines of Lieber, op. cit., vol. 1, p. 46.

about $45. It is said that the average of a shipment of ore from these veins gave smelter returns of $56. The mill was then erected, but at best saved only 60 per cent of the assay value, and a sample from the tailings pile showed a content of $34 per ton. The writer was told that the mill and the one table used were crowded, causing incomplete amalgamation and concentration, and that much fine pyrite was lost. The tailings certainly are very fine, and it is probable that a large proportion of slimes was formed. It would seem that the use of lighter stamps with low discharge and plentiful water feed and of both concentrators might raise the efficiency of extraction. More development might well be carried on, however, before further outlay is made on experiments in extraction.

The Dorothy vein strikes about N. 32° E. and dips about 80° SE. It ranges in width from 18 inches to 3 feet, with an average of about 30 inches. The outcrop is plainly visible for several hundred feet. A shaft has been sunk 106 feet on it and short levels run in each direction from the bottom. This shaft, being located high above a small creek which flows across the rock structure between it and the Schlegelmilch shaft, is dry. The air in the bottom is bad and necessitates the running of a blower when work is going on. But little ore has been taken from this place. It is said that the values fell from about $35 near the surface to less than $20 near the bottom of the shaft.

Darwin mine.—At this old mine, about 2 miles northeast of Smiths Ford of Broad River, little is now to be seen except the prominent outcrop of a northeastward-trending quartz vein, probably 5 or 6 feet wide. One or two pits and a shallow shaft on the vein are now so filled in that they expose nothing of interest. Little indication of sulphides is to be seen, although it is said that pyrite and chalcopyrite were fairly abundant.[a] The vein is reported to have been irregular, inclosing numerous horses of the wall rock and thus adding to the cost of mining. According to Lieber [a] some success attended the early operations. No work has been done for many years.

Ross & Carroll mine.—About three-fourths of a mile north of the Darwin mine is a quartz vein on which mining has been done intermittently for a long time and which was last worked some years ago by Messrs. Ross & Carroll, of Gaffney, S. C. It is often spoken of as the Wolf Creek mine. The vein, 2 to 2½ feet wide, outcrops on a prominent ridge and has been opened by several pits for about a quarter of a mile. At Wolf Creek the ridge is cut down fully 150 feet. The vein continues on the northeast side of the creek, and most of the workings, a tunnel and shallow shaft, are on that side. About fifteen years ago a stamp mill was erected at the creek and considerable ore put through. It is understood that the large proportion of pyrite, in which the gold was mainly contained, made the percentage of recovery low. The writer was told that a few tons of rich ore were hauled to Blacksburg for treatment, but that the returns, $52 per ton, were disappointing.

McGill mine.—This mine, a fraction of a mile northeast of the Ross & Carroll mine, is said to be on the continuation of that vein. Work was done many years ago, and again somewhat more recently by Maj. J. F. Jones, of Blacksburg. The vein is said to split up toward the northeast into a number of small veins too narrow and low in grade to be of profit. On the main vein two shafts, 90 and 80 feet deep respectively, were sunk and some good ore was taken from certain pockets or shoots rich in sulphides. It is learned that this ore averaged about $25 per ton.

McCaw mine.—About 2 miles southwest of Smyrna and 1 mile southeast of the McGill mine is a property worked in 1904 by Mr. W. B. McCaw, of Yorkville, S. C. A quartz vein striking N. 50° E. and dipping very steeply to the northwest occurs in a much decomposed schistose rock, probably amphibolite. The vein, which is something over 2 feet wide, has been proved for about 200 feet by several pits. A shaft 35 feet deep was sunk on the vein and drifts 30 to 40 feet long run in each direction. A little stoping was done above these drifts and a few tons of ore have been shipped, the value assigned being about $25 per ton. Pay ore was found only in bunches in the vein and values are said to have pinched out in the bottom, although the vein itself continues downward. The shaft is situated in low ground, and in consequence fills with water nearly to the collar when pumping

[a] Lieber, op. cit., vol. 2, pp. 56–57.

is not done. The ore from the bottom, nevertheless, is considerably oxidized. Work at this place was stopped in the autumn of 1904.

Love mine.—About 1 mile southeast of Kings Creek station and just east of the railway some work has been done on a quartz vein in schist. The vein is probably 3 feet wide on the average, strikes about N. 35° E. and dips about 70° NW. Several inclined shafts ranging from 30 to 50 feet deep prove the horizontal extent of the vein for a distance of 1,000 feet or more. Toward the northeast especially the vein is rather heavily impregnated with partially decomposed pyrite, which in some cases occurred as cubical crystals as much as an inch across. Several tons of the ore are now on the surface and it is said that a number of carloads have been shipped. The ore has a promising appearance, but it is of course impossible to judge of the value of such ore without assay. Reports as to value are not wholly concordant, some being to the effect that a part of the ore shipped gave returns of $80 per ton, while others declare that the ore is of low grade. If the value is good the extent and regularity of the deposit would seem to warrant further exploration. No work is being done at present.

Wilson mines.—About 6 miles northeast of Yorkville, in York County, S. C., near the road leading to Nannies Mountain, are situated the Big Wilson and Little Wilson mines. They are under the control of Mr. W. C. Latimer, of Yorkville, who furnished the greater part of the information which follows. In the forties oxidized ore from the Big Wilson is said to have been worked in an old mill of the arrastre type, in which oxen supplied the power. Later, when sulphide ore was struck, the ore was "burned" or roasted in kilns [a] and then treated after the same fashion as the oxidized ore. The water level was only a few feet below the surface, and although a Cornish pump was used water put an end to work at a depth of 65 feet. In the early part of 1885 work was resumed and a 10-stamp mill erected. It is stated that $18,000 had been recovered by the end of the year simply from sinking the shaft to the 92-foot point, and in the first six months of 1886 $6,000 was taken out. Work was again suspended till 1896, when a Mr. Clark is said to have extracted $12,700 from a six months' run and saved 40 tons of concentrates. No work of consequence has been done since that time. There are three shafts, each about 90 feet deep, of which two are now out of commission, while the most recent one, though nearly full of water, appears very well timbered and is said to be in good condition. These shafts are all connected at the bottom by a drift 120 feet long. There are a few other short drifts and crosscuts. A number of veins are said to be present on the property, but only one has been developed. This vein, inclosed in amphibolite, strikes N. 40° E. and dips approximately 75° SE. The writer was told that this vein has been opened at five different places in a distance of seven-eighths of a mile. It is about 4 feet wide at the surface, but is said to widen decidedly with depth. Pyrite is plentiful and is said to assay $30 to $40 per ton, while the average ore runs about $12. Along the foot wall of the vein chalcopyrite is said to be present in sufficient amount to make the ore important as a source of copper. Some specimens of free copper were seen, said to have been taken from narrow kaolin seams at the side of the chalcopyrite vein.

About a mile southwest of the Big Wilson is the Little Wilson property. It adjoins on the southwest the Mary mine, which was once exploited for the copper contained in quartz veins carrying chalcopyrite, as mentioned on page 112.

The Little Wilson vein is a big quartz body striking about northeast and dipping about 70° SE. Two inclines about 35 feet deep appear to be on the foot wall and hanging wall, respectively, and thus indicate a width of 20 feet in one place, but it may be that they are on separate veins of less width. A shaft 90 feet deep gets into quartz carrying finely granular pyrite arranged in rude bands parallel to the walls, but possessing few others of the features significant of crustification. It is said that some chalcopyrite was found near the bottom of this shaft. High assays are said to have been obtained from picked specimens, but the average run of the vein was not learned.

[a] Cf. Lieber, op. cit., vol. 1, p. 47.

The above statements regarding size and value of the ore bodies of the Wilson mines were not capable of verification by the writer and are given for what they may be worth.

Prospects.—A number of small workings of either old or recent making were visited in the course of the reconnaissance. These are briefly mentioned or described in the following paragraphs:

Some work was done in the early days on a quartz vein occurring on the property of George R. Wallis,[a] about 4 miles northeast of Yorkville, and desultory exploration has been carried on up to a few years ago. It is said that John W. Mackay worked here as a common laborer before going to California. One shaft is said to have been over 100 feet deep. A vein ranging from 1 to 4 feet wide, striking N. 75° E. and dipping about 70° NW., has been opened up at various places for about three-fourths of a mile. The country rock appears to be a sheared granite. Granite appears close by. A 100-foot northwesterly diabase dike appears to fault the northeast part of the vein 200 or 300 feet to the northwest. The quartz carries rather abundant pyrite, some of which, as concentrates, is said to run $100 per ton. It is reported that the ore averages $10 to $20.

Messrs. Small & Johnson are prospecting in a small way on two properties about one-half mile northwest of Smyrna, York County, S. C. On what is called the Allison (formerly Bolin) place some rather promising-looking quartz with decomposed pyrite has been encountered in a vertical vein about 15 inches wide, which strikes about N. 70° E. A 20-foot pit and a short tunnel comprised the development work at the time of visit. Not far from this, at the Bradley place, a 20-foot shaft has been sunk on what is said to be a vertical ore shoot 10 feet long in a 15-inch quartz vein. The values in the shoot are said to be good, while outside the shoot the vein is of very low grade. A little ore has been shipped to Perth Amboy, N. J.

The Horn property, in the town of Smyrna, is said to have within a few feet of each other, three parallel quartz veins striking about N. 38° E and dipping steeply to the southeast, which in places are rather heavily impregnated with pyrite. These it is said are cut by a pyrite vein striking N. 30° W. and dipping about 45° NE. As the shallow pits, which were sunk years ago, were either caved or completely filled with water, the writer was able to judge of this occurrence only from material on a small dump. This was quartz heavily impregnated with partially decomposed pyrite. It was stated by the owner, Mr. Horn, that a ton of ore shipped to Jersey City gave returns of $43 gold and 26 ounces of silver, while 2 tons shipped to a Norfolk smelter gave very low returns. If gold is present in the partially oxidized pyrite it does not appear on panning.

On the place of James Love, about a quarter of a mile west of Broad River, at Smiths Ford, a little tunnel and shaft work was done years ago on a good-sized vein of massive white quartz, in which no indication of sulphides could be seen. It is not known whether or not gold was found here.

About a mile north of Smiths Ford, on the east side of the river and about 12 miles southeast of Gaffney, is situated what is known as the Flint Hill mine. Several pits and two 50-foot shafts have been sunk on what appear to be two northeastward-trending quartz veins which carry pyrite, and are said to assay $11 to $16 per ton. The work was done many years ago and no information could be gained concerning the extent of the deposit.

At the Rosa Arrowwood mine, about 1 mile east of Smiths Ford, some good ore was taken from pockets in a northeasterly-trending quartz vein. The work was done years ago, and only a few old pits, partially filled and overgrown, remain to indicate that gold was ever present here.

The Mitchell place is about a mile south of the Rosa Arrowwood. A few years ago a vein was opened here which was heavily impregnated with pyrite, and the prospectors were much encouraged by the general appearance of the ore, but when assays were made

[a] Probably same as Wallace mine. See Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 77.

80 cents, was the best that could be obtained. A little placer work was done in the small creek just to the west, but is said not to have been profitable.

Farther to the southwest, about a mile from the Mitchell place, a vein striking N. 30° E. with steep dip to the northwest has been opened on the Parker property. Three short tunnels which appear to cut this vein show that it is very irregular in width, ranging from 4 feet down to 2 inches. The northeasternmost opening exposes a lens-like mass of quartz, 10 to 12 feet long, inclosed in decomposed schist, probably amphibolite. Farther southwest a 35-foot shaft and drift explore more of the vein. The quartz contains oxidized sulphides, which are said to carry fair gold values, although smelter returns from a small shipment were low.

A small, mound-like elevation known as Mose Mountain, just to the northeast of the Brown mine, is cut by many veins of "hungry" or barren-looking quartz, which, however, have received considerable attention from prospectors because of the story, presumably as ill founded as such tales usually are, that some very rich ore was once found there by an old miner, who died without disclosing the exact location of his find.

The Bolin mine, so called, is about 1 mile south of the old Darwin prospect. Several pits were sunk years ago on a quartz vein of northeasterly strike. Nothing further is known concerning this property.

On the Terry place, which adjoins the McCaw property on the northeast, a 30-foot pit on a vein of quartz afforded opportunity to take out a small amount of ore, which was shipped. The value of the ore was not learned. This work was done only a few years ago.

A little prospecting has been done on the Love property, about 2½ miles northeast of Yorkville, not far from the Wallis place. A 2-foot quartz vein striking to the northeast is irregular in form and includes horses of the schist wall rock. A streak about 4 inches wide in the middle of the vein, carrying decomposed pyrite, is said to assay as high as $50, while the remainder of the vein is lean. It is stated that some copper is present, but no indications of that metal were seen by the writer.

About 3½ miles southwest of Gaffney, on the Nott property, not far from the old Cameron lead mine, a couple of men were at work at the time of the writer's visit sinking a prospect shaft near the site of an old placer, which corresponds in description to the Austin placer of Lieber,[a] and which is said to have yielded $50,000 to $75,000. This shaft, which had attained a depth of about 20 feet, exposed only a 3-inch seam of quartz, with some decomposed pyrite. Work was stopped here in the early autumn of 1904.

Old abandoned mines.—For the sake of completeness the names of a number of old mines once more or less important, many of which have long since been forgotten, are given here. These names are taken from the early literature on the geology of this region and are arranged according to geographic position. In most cases more or less complete descriptions of these mines will be found in the references cited.

In Chesterfield County, S. C., the Leach[b] mine is near the Brewer mine, and was said to resemble that mine in the character of its ore deposit. The Kirkley[c] and McInnis[c] mines are also near the Brewer. Other old mines in the western portions of Chesterfield County are the Miller,[d] Huff,[d] and Hendrix.[e]

In Lancaster County, S. C., the Funderburk[f] and the Gay[g] or Little Brewer are near the Haile mine and are said to resemble it in character. The Ingram,[h] Clyburn,[i] Williams,[i] Belk,[j] Massey,[k] Stevens and Belk,[k] Phiffer,[k] and Knight[k] mines are also in the vicinity of

[a] Op. cit., vol. 2, p. 71.
[b] Lieber, op. cit., vol. 1, pp. 56, 68–69; vol. 2, p. 53. Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 77.
[c] Lieber, op. cit., vol. 2, p. 53. Nitze and Wilkens, loc. cit.
[d] Tuomey, M., Geology of South Carolina, 1848, p. 98.
[e] Lieber, op. cit., vol. 1, p. 69.
[f] Lieber, op. cit., vol. 1, pp. 59–60. Nitze and Wilkens, op. cit., p. 77.
[g] Lieber, op. cit., vol. 1, pp. 57, 62. Nitze and Wilkens, loc. cit.
[h] Lieber, op. cit., vol. 1, pp. 57, 63.
[i] Nitze and Wilkens, loc. cit.
[j] Lieber, op. cit., vol. 1, p. 55. Tuomey, M., Geology of South Carolina, 1848, p. 98.
[k] Lieber, op. cit., vol. 1, p. 55.

the Haile mine. The Potts,[a] Izell,[a] Johnson,[b] and Hagin[c] mines are situated elsewhere in Lancaster County.

In York County, S. C., the Wylie,[d] Kennedy,[e] Sutton,[f] and Palmetto[g] have been noted or described by previous writers.

The mines in Union County, S. C., which have not been described in the foregoing pages are the Bogan[h] and the Harman[i] or Mud[j] mines, both of which are situated in the northwestern part of the county not far from the Thompson and West mines.

The Lockhart[k] mine, near Limestone Springs (just south of Gaffney), in what is now Cherokee County, was worked in the early days of the Southern Appalachian mining industry.

In that part of Gaston County, N. C., with which this report deals the following mines have at some time been worked: Crowders Mountain[l] or Caledonia, Patterson,[l] Rhodes,[m] McLean[m] or Rumfeldt, and Oliver.[n] The Long Creek[o] or Asbury mine, 7 miles northeast of Kings Mountain station, is said to contain similar ore to that in the old Kings Mountain mine, being characterized by more or less uncommon minerals,[p] such as tetradymite, arsenopyrite, leucopyrite, bismutite, and bismite.

In the southwestern part of Union County, N. C., the Howie (now Colossus), Wyatt, Washington or Bonny Belle,[q] and Penman mines collectively made up what was known as the Grand Union gold mine.[r] Numerous other mines to the north and northeast in Union County and to the northwest in Mecklenburg County have been worked, but fall outside the area here described.

SUMMARY.

The locations of the mines of this area, outlined above, indicate two broad belts along which gold has principally been found. These two belts have been generally recognized by most writers heretofore. They trend northeastward in a general way parallel to the strike of the rocks and the general structure of the region. One belt extends from the western part of Union County, S. C., through eastern Cherokee and western York counties, S. C., and on through the eastern half of Gaston County and western Mecklenburg County, N. C. The other belt is broader and in a measure less defined. It includes Lancaster County, eastern York and western Chesterfield counties, S. C., and Union County and the eastern edge of Mecklenburg County, N. C. Scattered mines or occurrences of gold are known between these two belts.

To the south of the area which forms the subject of this report these belts become indistinct, but their continuation is probably represented by a number of gold deposits in Laurens, Abbeville, and Edgefield counties, S. C., and in McDuffie, Warren, Wilkes, Lincoln, and Columbia counties, Ga.[s]

To the north these two belts merge into one rather indefinite zone, including Lincoln, Catawba, Cabarrus, Stanley, Montgomery, Moore, Randolph, Rowan, Davidson, and Guilford counties, N. C. Taken collectively, this Carolina belt, as it is called, has been one of the most important gold regions of the eastern United States.

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[a] Lieber, op. cit., vol. 1, p. 50.
[b] Lieber, op. cit., vol. 1, p. 69.
[c] Lieber, op. cit., vol. 2, pp. 49–50.
[d] Lieber, op. cit., vol. 1, p. 45.
[e] Lieber, op. cit., vol. 2, p. 63.
[f] Lieber, op. cit., vol. 2, p. 48.
[g] Nitze and Wilkens, loc. cit.,
[h] Tuomey, M., Geology of South Carolina, 1848, p. 92. Lieber, op. cit., vol. 2, pp. 66–67.
[i] Tuomey, M., op. cit., p. 91.
[j] Lieber, op. cit., vol. 2, pp. 57–58.
[k] Tuomey, M., op. cit., p. 88.
[l] Kerr and Hanna, Ores of North Carolina (chap. 2 of Geology of North Carolina, vol. 2), 1893, p. 306. Nitze and Hanna, Bull. North Carolina Geol. Survey No. 3, 1896, pp. 147–148.
[m] Nitze and Hanna, op. cit., p. 148.
[n] Nitze and Hanna, op. cit., p. 149.
[o] Kerr and Hanna, op. cit., p. 304. Nitze and Hanna, op. cit., p. 149.
[p] Becker, G. F., Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 274–278. See also pp. 62–63 of this report.
[q] Nitze and Hanna, op. cit., p. 104. Becker, G. F., op. cit., p. 310.
[r] Kerr and Hanna, op. cit., p. 261.
[s] Cf. Nitze and Wilkens, Bull. North Carolina Geol. Survey No. 10, 1897, p. 84.

At the time of the writer's visit (autumn, 1904) the Haile mine was in active operation, the Blackmon was working a force temporarily reduced on account of scarcity of labor, the Brewer and Thompson were working in a small way under lease, the Ferguson, Brown, and Schlegelmilch were carrying on development work, Messrs. Small & Johnson were exploring their properties near Smyrna, and extensive work was going on at the Colossus mine preparatory to beginning active mining and milling. In addition to these operations a few individuals were washing stream gravels for placer gold. So far as known, no other mining for gold was being done in this region. Since that time work at the Brown and Schlegelmilch mines has been stopped.

CONCLUSIONS.

The condition of the gold-mining industry in this region to-day is fairly well outlined in the preceding paragraph. In 1859 there were in the South Carolina portion alone 40 working mines,[a] and it is probable that the decrease in the North Carolina portion has been of about the same order of magnitude. Furthermore, most of the mines now working were then known and were mining richer ores than at present. If these former conditions are compared with the present status, it is at once apparent that the gold-mining industry of this region has suffered a decided decline. The fact that a very few mines (of which the Haile is really the only one of importance in this respect, as will be shown presently) have been able to maintain and even increase the total production of earlier years is not surprising in view of the advances which mining as an industry has made, and in reality has little to do with the consideration of this district as a whole. For the last fifteen years or thereabouts only a small addition to the production of this region has been made by any but the Haile mine, which has maintained its average yearly production at something like $100,000 during that time. This mine has been compelled to reduce more and more the cost of operating per unit of product, because of decreasing grade of ore, and has been forced to gradually encroach on and deplete its known reserves of workable ore, so that the time is not far distant when a falling off in production must be expected unless some of the development work now being carried on can bring to light new supplies of ore.

So far as the other mines are concerned, it may be said that in spite of the unsystematic and unscientific management which has been the rule rather than the exception in this region, most of them which seem to have possessed any sign of promise have been given a pretty fair chance to show what they are worth. In the case of the Colossus, it seems safe to say that if the ore bodies are as persistent as those at the Haile have been—a statement which there may be no reason to doubt, but which ought to be demonstrated—if the ore averages as well as the reported assays indicate, and if the cyanide process now being applied proves a successful means of extraction, then a good production may be expected for some years. The Blackmon mine likewise may make a respectable addition to the output of the region if the size and value of the deposit persists and certain obstacles to mining, already enumerated, can be overcome. There appears little reason to hope that the Brewer mine will ever again become an important producer. While much gold undoubtedly exisits in that immense deposit, it is doubtful if it can be extracted with profit. Little can be said of the Kings Mountain mine, because of lack of authentic information, but it is unreasonable to suppose that it would now be lying idle if much ore of the grade which it has already furnished were known to exist. Certain of the smaller mines may, and probably will, prove profitable for a period, but in the case of the vein mines the irregularities of the deposits will make mining an uncertain enterprise and the relatively small size of the ore bodies will demand that the value of the ore must remain fairly high as compared with that of the large replacement deposits.

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[a] South Carolina, Resources, etc., State Board of Agriculture, Charleston, 1883, p. 134. There were, in 1859, 21 working mines in Lancaster and Chesterfield counties and 19 in Spartanburg, Union, and York counties. These three last-named counties were a few years ago divided, portions of each constituting a fourth county, Cherokee. It is certain that of these 19 mines, nearly all of which were situated in the old Spartanburg County, are now included in Cherokee County, and are thus within the area studied.

It must be remembered also that in both classes of deposits increasing depth will in general mean increasing cost of production, especially in this region where there is no apparent solution of the water problem except by pumping. A further serious handicap to success is the fact that in nearly all the mines the decomposed ores, which allowed comparatively easy extraction of the gold, are now almost or quite exhausted, and that the sulphide ores to which operators now must look for future production can be treated only if rich enough to warrant being shipped to a smelter, or, if of lower grade, only by the outlay of considerable capital in the erection of a plant for concentration, if not for roasting and lixiviation also.

Finally, there arises the question of discovery of new mines or ore bodies. There is little doubt that there exist in this region many deposits of gold which are now unknown. When it is remembered, however, that prospecting has been going on more or less actively right here for nearly a century, with only unimportant results in recent years, and that for a decade or two before the war this was distinctly a mining region where practically the whole population was incited to activity by the possibility of discovering gold, and when it is considered what great amounts of money must have been spent in the early stages of exploratory development, one can but admit that the ground has been pretty carefully searched. Add to this the fact that probably a great proportion of the placer gold, which in the early days aided materially in the location and discovery of the deposits in place, has been removed, and it becomes plain that the prospect for any important addition to the localities of gold now known is not bright.

In conclusion, then, it seems probable that if the production of the region is to be maintained or increased, this will be due to a few large mines, and that more likely the future will bring to this region a gradual decline in importance, both relative and actual.

OTHER MINERAL PRODUCTS OF THE REGION.

SILVER.

Silver has never been found in commercial quantities in this area, and so far as known no distinct silver mineral has been reported. The metal is not wholly absent, however. It probably constitutes a large part of the material which brings down the fineness of the gold bullion to an average of about 0.900. It also probably occurs in the galena and tetrahedrite of the Kings Mountain mine and was said to be present to the extent of about 50 ounces per ton[a] in some of the ore from the old Cameron lead mine in Cherokee County, S. C. Silver occurs in some quantity at the Silver Hill mine in Davidson County, N. C., but on the whole is not very plentiful in the Southern Appalachians.

COPPER.

Copper occurs in many parts of the area, as may be seen from an examination of the list of minerals given under gold (pp. 62–63), but in nearly all cases the amount is so small as to be negligible. Chalcopyrite is the most common copper-bearing mineral, and has been found at the Kings Mountain, Ferguson, Big Wilson, and Colossus gold mines; at the Mary copper mine; at the Cameron lead mine; at the Jones tin mine, and at other places. At the Brewer mine enargite, the copper-arsenic sulphide, occurs in small crystalline grains in the blue siliceous gold ore. By decomposition it furnishes covellite (cupric sulphide), and on complete oxidation chalcanthite, the hydrous cupric sulphate, is produced. The chalcanthite forms blue coatings on the walls of the open pit wherever recent work has not been done. It is also noted by Becker in the Kings Mountain mine, forming a blue slime on the walls. Chrysocolla is said to occur in an old shaft of the same mine. Metallic copper is said to have been found at the Nott mine in Union County, S. C. From the description of the occurrence there it seems probable that this copper is a product of secondary enrichment from original sulphide ores above. Pyrrhotite, probably copper bearing, is found at

[a] Cf. Lieber, op. cit., vol. 2, p. 78.

the Kings Mountain, Colossus, and Haile gold mines; at the Cameron lead mine, and at the Jones tin mine. It is likely that much of the pyrite of the gold mines contains a small percentage of copper. Tetrahedrite is said to have been found at the Cameron lead mine.

The only place at which copper is known to have been sought is at the Mary mine, about 5 miles northeast of Yorkville, S. C. This mine was considered by Lieber[a] to offer very favorable indications. The country rock is a dioritic species originally containing fairly calcic plagioclase, hornblende or augite, ilmenite, and sphene. Regional metamorphism converted the original bisilicate into secondary hornblende and the plagioclase into oligoclase or andesine, abundant epidote, and a little zoisite. Metasomatic alteration along the sulphide-bearing quartz veins has almost completely converted the uralite into brown biotite and has changed much of the feldspar into sericite; pyrite has also been introduced. The quartz itself carries both pyrite and chalcopyrite in large and small crystalline masses and grains. From the statements of Lieber regarding the occurrence of secondary minerals arranged in vertical zones, it seems probable that leaching of the upper, oxidized portions of the vein has resulted in secondary enrichment below. It is interesting to note, in this connection, in what clear terms Lieber described certain features of the process now known as secondary enrichment.[b] It is probable that the "black oxide" which he describes as occurring just above the primary pyritic ore was in reality the sulphide, chalcocite. A large quartz vein, apparently barren, occurs a short distance from the copper-bearing vein. Several pits have been sunk, and it is rumored that some ore was shipped to Charleston during war time and was manufactured into shells, but this seems to be without foundation.

LEAD.

Lead is known to occur at the Kings Mountain gold mine as galena and as nagyagite. A more important deposit was known as the Cameron mine and earlier as the Morgan or Leitner mine.[c] This mine is situated just east of the limestone belt of the Kings Mountain Range and is about 4 miles southwest of Gaffney, S. C. It was opened before the war as a copper mine, but lead was soon found to be the most important metal present. During the war the demand for lead for bullets caused active work to be carried on at this place.

The country rock is amphibolite, cut by a granitic gneiss containing a small amount of albite, showing crushing, particularly along certain bands, and undoubtedly closely related to the granite of the tin belt.

The vein, which was said to be 2 to 2½ feet wide, is parallel to the foliation of the country rock and consists principally of quartz, coarsely crystalline siderite, and chlorite. The ore minerals are galena, decomposing to cerussite and leadhillite, and wulfenite (lead molybdate). The small needles of pyromorphite, the phosphate, found with quartz in vugs are also probably secondary. Pyrite, chalcopyrite changing to covellite and malachite, pyrrhotite, and arsenopyrite are sparingly present in the quartz. "Gray copper" (tetrahedrite?) is said to have been found here. Thin botryoidal coatings of brown iron oxide, showing beautiful radiating structure, line many cavities in the vein. The galena is said to contain considerable silver, the amount per ton of ore in one lot of metal being reported as 49 ounces.[d] Gold is also said to have been present.[e] The development consisted of two shallow tunnels and an inclined shaft nearly 150 feet deep. The writer is informed by Capt. A. Thies, who worked the mine for the Confederate government, that not much lead was present and that the total output of the mine amounted to a few hundred tons. It was at one time contemplated to work the siderite for iron.

Rich galena ore occurs at the Black mine, near Indian Trail, Union County, N. C., just outside the area contained in this report, but the quantity was not ascertained.

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[a] Op. cit., vol. 1, pp. 82–83; vol. 3, p. 199.
[b] Op. cit., vol. 1, p. 84; vol. 2, pp. 11–12.
[c] Lieber, op. cit., vol. 1, p. 86; vol. 2, pp. 74–78. Shepard, C. U., Report on the Morgan Silver-Lead and Copper Mine in Spartanburg District, S. C. London, 1855.
[d] Lieber, op. cit., vol. 2, p. 78.
[e] Lieber, op. cit., vol. 3, p. 198.

ZINC.

With the exception of a small amount of sphalerite found at the Kings Mountain mine, no zinc is known in this area.

IRON.

Considerable activity was once manifested in this region in the mining of this most essential of the metals. Of the several iron-producing regions in the Carolinas, that along the Kings Mountain Range was in the early days one of the foremost. The Hills Iron Mining Company is said to have worked before the Revolutionary war a deposit occurring on Nannies Mountain, about 12 miles northeast of Yorkville. The Swedish Iron Mining Company in the vicinity of Cherokee Falls and the Kings Mountain Iron Mining Company in the vicinity of Kings Mountain carried on rather extensive operations before and during the civil war. More recent work has been done at the Ormond mine, northeast of the town of Kings Mountain, N. C., and at several places south, southwest, and southeast of Blacksburg, S. C. Nothing is being done at present.

Owing to the fact that nearly all the workings are inaccessible or because they are either caved in or filled with water, a satisfactory idea of the character of these deposits was not obtained. The only place where geologic relations are adequately exposed is at what is known as the No. 2 magnetite pit, about 2½ miles south-southwest of Blacksburg and only a short distance southeast of the limestone belt. This is a cut 50 to 60 feet long, 30 feet wide, and about 30 feet deep. There is at present about 12 feet of water in the pit. The rock, which is a dark slate, strikes about N. 60° E. and dips very steeply to the southeast, although there appears to have been considerable folding and contortion. Masses of dense blue-gray rock occurring in several places may be basic eruptive material. Magnetite is irregularly distributed through the slate in disseminated grains, large and small enses, and shapeless masses. Associated with it, in bunches and veinlets, is a white fibrous material, locally called serpentine, which proves to be mostly actinolite, although some serpentine and a little carbonate are present. The slate consists of extremely fine shreds of serpentine with a small amount of carbonate and a few fragmental grains of a pale-greenish amphibole probably actinolite.

The origin of this ore is uncertain. The association with serpentine may indicate that the magnetite is a segregation from a basic igneous rock, the whole having then been subjected to folding and consequent metamorphism.

This magnetite is said to be of very good quality. Considerable was mined and used before and during the civil war in the furnaces along Broad River. Remains of some of these furnaces are still to be seen. Several tons of ore are at present piled up near the pit. From its appearance the writer would judge that its content of iron is rather too low to be profitable, and it is questionable if high-grade ore can be mined from this deposit.

About one-fourth of a mile farther northeast a pit which is probably on the same deposit exhibits similar conditions. The slaty rock shows better foliations, dipping very steeply to the southeast. Iron appears less abundant.

At several points along the eastern side of the Blacksburg fold and near the quartzite ridges occur deposits of iron oxide. Some of these are limonite, some hematite, some magnetite, and some mixtures of any or all. This belt is known to extend from a mile or two south of Broad River through Cleveland, Gaston, and Lincoln counties and into Catawba County. Following closely along this iron belt through nearly its whole extent is a band of manganese oxide.

Considerable work was once done on the south side of Broad River. Before the Michigan and Alabama fields were worked these deposits furnished a great part of the iron locally consumed, and it is said that some was shipped away. Other workings were located in Gaston and Lincoln counties. Deposits of this kind are known on the ridge north of Cherokee Factory, in Cherokee County, and in the vicinity of Wolf Creek, near the York County line. At the latter place, on property of Mr. W. B. McCaw, a deposit of solid crystalline

hematite occurs. The iron ore is also disseminated through the wall rock for some distance away from the main body. The surrounding rock is much decomposed, but is probably a quartz-sericite schist. It is said that the iron is of good grade and contains only small amounts of sulphur and phosphorus. If the pits which have been dug give any idea of the extent of the deposit, little can be expected of it from the commercial standpoint. The same statement may be applied to all the other deposits of this type which have been visited.

It seems not unlikely that these bodies represent deposits of bog iron ore buried by later sediments and then subjected to metamorphism which converted much of the limonite into hematite and in part even to magnetite. Such an origin would explain the small extent and the discontinuity of the deposits. A small deposit of limonite ore in decomposed schist has been opened in shallow pits on the property of William Martin, about 3½ miles northwest of Blacksburg and just over the line in Cleveland County, N. C. The interbedding of the deposit with the surrounding slates suggests that it likewise originated from bog iron ore.

South of Kings Mountain the Kings Mountain Range breaks up into smaller mounds and separated ridges. East of Blacksburg on one of these ridges some pits have been sunk on iron-rich places in the schist, and a comparatively small amount of ore has been taken out. It consists of both limonite and hematite, but at a depth of 20 to 25 feet becomes pyritic and soon passes into solid pyrite.

Ore of a similar nature has been found on the knob just south of Broad River not far from Cherokee Falls. Open cuts of considerable size furnished ore for several blast furnaces and bloomeries situated along the river in war times. These old openings are now nearly filled with débris and material from the caving of the walls. The ore here is not so certainly derived from pyrite as that on the north side of the river just above, but the similarity in appearance and occurrence of the oxide ores is great.

Iron of good grade occurring in streaks or vein-like masses was once mined to a small extent from the Ross property, near Wolf Creek.[a] Here, too, the percentage of sulphur increased with depth, and finally, it is said, the ore became such massive pyrite that it was used for the manufacture of sulphuric acid.

During Revolutionary times iron was mined at the Hills iron works on Nannies Mountain, York County. The rock, an impure foliated quartzite, is cut by a "vein" which strikes N. 15° E. and dips 80° to 85° E. Where best exposed it is 6 feet wide, but must have been much wider in places, to judge from the width of some of the pits on it. This band is composed of mixed limonite and hematite, much of it porous. Near a small stream which crosses the belt a shallow pit reaches granular quartz heavily impregnated by pyrite. It is evident, therefore, that the iron mined was simply the oxidized cap of a pyrite vein. It is said that prospecting by means of a diamond drill showed a heavy body of sulphides, partly pyrrhotite, at a depth of 400 feet. It seems probable that oxidation of this deposit has been pretty complete down to water level, while below that the sulphides are little altered.

It is probable that these sulphide bodies represent veins and fahlbands and are distinct in origin from those deposits which are believed to have accumulated in bogs.

The Ormond mine, about 5 miles northeast of the town of Kings Mountain, has been more developed than any of the iron deposits in the district described. At the time of visit the workings were inaccessible, and little but waste was to be seen on the dump. A rather full description of the mine is given by Nitze.[b] The main shaft, 173 feet deep, encountered some good ore bodies at the bottom, considerably below present water level. On the other hand, masses of pyrite and pyrrhotite [c] have been found in various portions of the workings. Manganese, nickel, and cobalt oxides have been found with the ore.[d]

[a] See Lieber, op. cit., vol. 1, p. 89.
[b] Bull. North Carolina Geol. Survey No. 1, 1893, pp. 93–102.
[c] Wurtz, H., Proc. Am. Assoc. Adv. Sci., vol. 12, 1859, p. 223; Am. Jour. Sci., 2d ser., vol. 27, 1859, p. 26. Cf. also Tuomey, M., Geology of South Carolina, 1848, pp. 81–83.
[d] Wurtz, H., loc. cit.

Whether this ore was once a sulphide that is now oxidized below the water level or whether original oxide ores are present along with pyrite the writer is unable to say.

The presence of gold in an old iron deposit known as the Bird bank, mentioned by Tuomey,[a] may be an indication that the deposit was the gossan of a sulphide vein.

In conclusion it may be said that so long as the great sources of present supply of iron maintain their productiveness there seems little hope of the deposits of this portion of the Carolinas assuming much commercial importance.

MANGANESE.

So far as known no manganese has ever been produced in this region, although it has long been known to occur. Mention has already been made (pp. 26, 114) of the black belt carrying manganese, which occurs on the east side of the Blacksburg fold. In places the percentage of manganese is high and ought to warrant more exploitation than the few shallow pits which have been sunk east of Blacksburg. Analyses of specimens from this place by Nitze [b] run up to 57 per cent of metallic manganese. A qualitative examination of this manganese ore by Dr. E. C. Sullivan, of the United States Geological Survey, shows that it contains traces of both nickel and cobalt.

It seems probable that these deposits are metamorphosed bog ores. On the property of Dr. F. H. Morton, near Draytonville Mountain, about on the strike of this manganese belt, a depression of several acres in extent is covered with a layer of concretionary manganese oxide, with some iron, mixed with a small amount of clay—a typical bog ore. It has probably been derived by decomposition of the manganiferous belt. It is possible that a sufficient amount of ore of suitable grade is present to make the deposit valuable.

PYRITE.

Some years ago pyrite was mined a few miles north of Kings Mountain and was used by the Virginia-Carolina Chemical Company for the manufacture of sulphuric acid. For reasons which were not learned operations were suspended, and in 1904 the machinery was being hauled away.

A plant near Blacksburg, erected some years ago for the purpose of manufacturing sulphuric acid and iron paint from pyrite, and at the same time recovering any gold which the sulphide might contain, obtained most of its ores from mines in the northwestern part of York County, the Ferguson, McGill, and Ross & Carroll mines being among the number. The general report is that the process was not successful.

GRAPHITE

Bands of graphite occurring as members of the rock series which makes up the Kings Mountain Range attain in places a thickness of 20 feet, but the mineral is said in general to be too impure to have commercial value.

BARITE.

Barite is said to occur in considerable amount on the eastern side of Kings Mountain. Specimens indicate that some of it is rather pure. Mining was carried on for some time up to about three years ago, and the output, which was shipped, reached at times 20 wagon loads per day. Recently no work has been done.

MONAZITE.

Beginning about 3 miles west of Gaffney, the rare-earth phosphate, monazite, occurs along a northeasterly belt which, with a short gap near Broad River, continues into Cleveland County, N. C. To the south the monazite belt is known to reach nearly to Greer, Greenville County, S. C. The most extensive deposits occur in the northern portion of this belt,

[a] Op. cit., p. 88.
[b] Bull. North Carolina Geol. Survey No. 1, 1893, p. 112.

outside of the territory embraced in this report, but considerable of this mineral has been obtained by placer-mining methods in the western part of Cherokee County, which is within the area here described.

On Cole Creek, about 3 miles west of Gaffney, are situated the Littlejohn and Huskey workings. The Littlejohn deposit, near the head of the creek, has been worked over several times 20 or 30 feet wide along the creek. The soil at farther distances shows considerable monazite on panning, but the distance to water is too great to make recovery profitable. At the time of visit Cole Creek was so low that but little washing could be done.

The Huskey placer adjoins to the south, or downstream. The workings here have been wider, owing to richer ground and more water. This deposit likewise has been worked over several times, giving each time a profitable amount of monazite. Two small branches of Cole Creek come in from the west on the Huskey property, and the southern one of these has been very rich.

The Lemon mine, about three-fourths of a mile north-northeast of the Littlejohn, has been the most productive deposit in the region. Situated on the forks of a small stream at its junction with Cherokee Creek, the workable area is comparatively extensive. Rich bars have been found to contain as much as 30 per cent of monazite.

About a mile still farther northeast, on a small stream running southeast, are the Magness, Swafford, Jones, and Sarratt placers, the latter said to be controlled by the Welsbach Company. These are said to have produced well. They are not being worked at present.

All these placers are situated practically at the source of the monazite. So-called ledges exposed in the stream cuts carry monazite as a constituent of the rock. These ledges, which have every appearance of dikes, cut a country rock of greenish-gray garnetiferous schist. They consist of quartz, feldspar, and brown biotite, and according to the proportion of the mica are either light or dark in color. The dark ledges are more common. In all cases observed these ledges are intercalated with the surrounding schist. Although somewhat crushed, showing a faint augen structure which might class the rock as a gneiss, these ledges exhibit plainly the intergrowth of quartz and feldspar characteristic of pegmatite dikes, and microscopic evidence is confirmatory. These dikes have already been described (pp. 20–22). The monazite occurs as an original constituent of the dikes in crystals which usually have well-developed faces and which range in size from microscopic to half a centimeter in diameter.

It is possible that monazite also occurs as an impregnation in the schist near the pegmatite dikes, but the writer found no proof of this. An interesting feature in connection with these dikes is the presence in them, apparently as an original constituent, of numerous scales of graphite. So far as known, no apatite has been found associated with the monazite in this region. Cerite, a rare-earth silicate, in specific gravity and appearance similar to monazite, is said to occur in considerable quantity at some of the mines, and being incapable of separation from the monazite by any method yet devised seriously affects the value of the product. In a few cases, where the richness and the degree of decomposition of the dikes permit, they are worked in the same way as the gravel, being washed through a screen and caught in a sluice box; but in general the sticky kaolin resulting from the decomposition of the feldspars makes thorough washing and complete recovery difficult.

While the gravel or soil at some distance from the streams not uncommonly contains as high a percentage of monazite as is found in the stream bed on the second and subsequent washings, it is in few cases profitable to work such deposits. The mineral from this source, however, serves to replenish the supply in the streams, being carried in by the heavy rains. That the stream gravels can be worked with profit several times is probably owing as much to this fact as to the low recovery of the early washings.

The region seems to have been pretty thoroughly prospected, and there can be little doubt that the richest ground has already been found and exhausted. Mr. M. E. Gettys, of Gaffney, is principally interested in these deposits.

A little monazite has been found on the Perry place, near Gaffney, and at several localities in the northern part of York County.

LITHIUM.

The occurrences of spodumene, mentioned on page 48, may be worthy of investigation as a source of lithium or even as a possible locality for the spodumene gems—kunzite, hiddenite, triphane, etc.

MICA.

Although some prospecting has been done on pegmatite dikes northeast of Kings Mountain station and northwest of Blacksburg, mica has never been found in commercial quantities in this immediate region, although not far to the northwest the mica industry is one of importance.

CORUNDUM.

Corundum is known to occur in the vicinity of Nannies Mountain in York County, and has been reported from the Perry place, just west of Gaffney. At two places near Nannies Mountain it has been mined. On the Barron property, southeast of the summit, a few shallow shafts have been sunk and some of the mineral obtained. The workings are now in such condition that they show nothing of the occurrence, and no rock is exposed near by. At the Clinton place, 1½ miles northwest of Nannies Mountain, some pits and trenches and a 30-foot shaft constitute the development work. These also are caved in and grown over with grass, so that no good idea of geologic relations can be obtained. A few rods away a decomposed granitic rock cut by diabase is exposed. Some corundum is piled up near the pits and shows decomposition into muscovite. Some of the mineral occurs in masses a foot in diameter, with imperfect radial structure. It is said that several tons have been shipped from this place by Rickard & Hewitt, of Brooklyn, N. Y., who control both this and the Barron property. Float is rather plentiful for some distance northeast of the Clinton place.

LIMESTONE.

Besides a fairly wide use as building stone in this region, the limestone of the Kings Mountain belt has been rather extensively quarried and burned to form lime. Quarries, now abandoned, have been made at Kings Mountain and at Blacksburg, and two quarries of good size (see Pl. II, p. 18) are now being worked at Gaffney, where a number of continuous kilns with iron shells produce about 200 barrels of lime daily. The crystalline rock, almost white, is said to produce so low a grade of lime that but little of it is used, while the blue compact rock furnishes a lime of good quality. The crystalline variety is probably rather dolomitic. (See analyses, p. 19.)

CLAY.

Near Grover, N. C., clay from some beds of comparatively small extent is shipped to Richmond, Va., and is said to be used for pottery and as fire clay. A deposit occurring 6 miles southeast of Gaffney furnishes material for a small oven which produces rough pottery.

THE GOLD DEPOSITS OF DAHLONEGA, GA.

By WALDEMAR LINDGREN

INTRODUCTION.

The gold mines of the Southern States, especially of the Carolinas, Georgia, and Alabama, have during the last decades declined in importance, and they have also been eclipsed by the larger production due to successive discoveries in the Western States. In consequence of this they have not in recent years obtained their share of attention from geologists. But it must not be forgotten that they were the first gold deposits which were studied by American geologists, and that about forty to sixty years ago they received much attention by such men as Silliman, Rogers, Whitney, E. Emmons, Lieber, and Kerr. The results of their studies were naturally applied to such western discoveries as the California gold-quartz veins, and thus the conceptions of "lenticular masses" and "segregated veins" were improperly transferred to western occurrences. No doubt the southern gold veins and those of California present some striking features of similarity, but the profound differences were overlooked, and the correct view of the latter as sharply defined fissure veins has only lately found acceptance in the general literature of ore deposits.

The first modern geological investigation of the southern gold deposits was made by Dr. G. F. Becker in 1895,[a] and his results throw much light on their mode of formation and aid in their proper classification. Since then detailed descriptions of many mines have been published by the State geologists of North Carolina and Georgia. When Mr. L. C. Graton was detailed to the investigation which forms the subject of this report, namely, the examination of the gold and tin deposits of the central portion of the Carolinas, it was my hope that, besides the practical results, some data on which to base conclusions as to origin might be gained, and a perusal of the bulletin will show that this hope was justified. After visiting some of the principal occurrences in the region under investigation, Mr. Graton and myself made a brief trip to Dahlonega for the purpose of comparing these veins with those farther north. The notes obtained, as well as some general conclusions, will be found in the following paragraphs, and, though very incomplete, may serve to fix a little more sharply than has been done before the group in which these deposits belong and some of their more striking distinctions compared with the gold deposits of the Cordilleran region.

GENERAL GEOLOGY.

The mines of the Dahlonega district of Lumpkin County, Ga., have been described in more or less detail in several publications. Among them should be mentioned the "Reconnaissance of the gold fields of the Southern Appalachians," by Dr. G. F. Becker,[b] and "The present condition of gold mining in the Southern Appalachian States,"[c] by Messrs. Nitze and Wilkens. Besides these, Dr. W. S. Yeates published, in 1896, as State geologist of the Georgia Geological Survey, "A preliminary report on a part of the gold deposits of

[a] Gold fields of the Southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 251-331.
[b] Sixteenth Ann. Rept U. S. Geol. Survey, pt. 3, 1895, pp. 251-331.
[c] Trans. Am. Inst. Min. Eng., vol. 25, 1896, pp. 661-796, 1021, 1025.

Georgia."[a] Finally, Mr. Edwin C. Eckel has recently described the "Gold and pyrite deposits of the Dahlonega district,"[b] in "Contributions to economic geology for 1902."

It will be seen from this list that the district has received a considerable amount of attention, and that the main features of the occurrence of the mineral deposits are fairly well known. It is not the purpose of the present contribution to present a detailed description, nor a complete one, of the Dahlonega mines. Indeed, for such a purpose the time allotted was by far too short. It is intended, however, to bring out in a little more detail than has been done before a few of the petrographic and mineralogical features, by which, perhaps, a somewhat clearer light may be thrown on the true character and origin of that peculiar class of deposits to which these gold-quartz veins belong.

The general geology of the district has been outlined by several of the writers mentioned above, especially by Eckel, and to the description of the main relations of the rocks there is but little to add.

The two most common rocks of the district are a mica schist and an amphibolite. The mica schist, which is the prevailing rock, is exposed, for instance, at the Preacher Cut, at the Benning mine, along Yahoola Creek, and in many other places. The rocks strike in general about N. 60° E. and dip at a high angle to the east, but both strike and dip are subject to abrupt variations. The mica schists are, in general, dark gray to dark brown and medium to fine grained. In places they approach perfect fissility, but ordinarily show curved and irregular surfaces of schistosity which are covered with glistening scales of biotite and muscovite. One of the most typical rocks is that exposed at the Preacher Cut, about one-half mile south of the town of Dahlonega. (See fig. 15.) This is a fine-grained brownish-gray schist. The small flakes of biotite have accumulated on the cleavage faces, which show fairly good fissility. Under the microscope the rock shows quartz mosaic with very few feldspar grains. Embedded in this mosaic lie abundant idioblasts of magnetite; brownish-green biotite in parallel orientation; straight, small muscovite foils, also mainly extended along one plane; and finally, rather abundant, well-developed, small bluish-gray prisms of tourmaline. The structure is typically crystalloblastic, to use the term recently introduced by Prof. F. Becke, of Vienna.[c]

The origin of a rock so thoroughly recrystallized as this is always open to some doubt, but I consider it reasonably certain that the quartz-mica schist of the Preacher Cut is of sedimentary origin. The consensus of opinion thus far regarding the mica schists appears to be that they are not indisputably sedimentary rocks. The normal schist of the country, wherever good exposures are available, proves to be similar to this specimen just described, although the grain is usually somewhat coarser and the sedimentary origin, though probable, is less distinctly indicated. A specimen of dark brownish-gray mica schist, from the Jumbo mine, shows again a mosaic of quartz, with a few grains of albite. This mosaic contains abundant dirty-brown, sharply outlined foils of biotite and smaller ones of muscovite. Pyrrhotite is present in small anhedrons, but no muscovite was observed. The structure here also is typically crystalloblastic.

No further clew has been found as to the age of the schists. They have, in common with all the other rocks of the district, been regarded as pre-Cambrian by Becker and other observers, but Eckel is inclined to question this conclusion and thinks that they may possibly be of Cambrian or Lower Silurian age. So far as known, however, no Cambrian rocks in the South are intruded by granite, but, as is shown on page 122, these mica schists contain considerable bodies of such intrusives.

As emphasized by previous writers, several large and irregular bodies of amphibolite occur in the district, as well as in adjoining regions. The contacts beween amphibolite and mica schist are usually sharply defined. In some places, as at the Preacher Cut, the relation of the two rocks decidedly indicates that the amphibolite is intrusive into the

[a] Bull. Georgia Geol. Survey, No. 4-A.
[b] Bull. U. S. Geol. Survey, No. 213, 1903, pp. 57-63.
[c] Ueber Mineralbestand und Struktur der kristallinischen Schiefer: Sitz.-Ber. d. Wiener Akademie, May 7, 1903.

mica schist and that it was originally a diorite or a diabase which has been deeply altered by dynamometamorphic processes. The strike and dip of the schistosity is, in general, conformable to that of the mica schists, but this again is subject to some marked exceptions. The strike and dip of the schistosity vary considerably from place to place.

The amphibolite is well exposed in the town of Dahlonega, near the Preacher Cut, and on the road from Dahlonega to the Lockhart. The amphibolite from the dump of the Crown Mountain mine, at the mill below the Preacher Cut, is a typical, dark-green, roughly schistose rock of medium grain, in which, by the naked eye, may be distinguished small prisms of amphibole with specks of pyrrhotite. In places narrow streaks appear in which

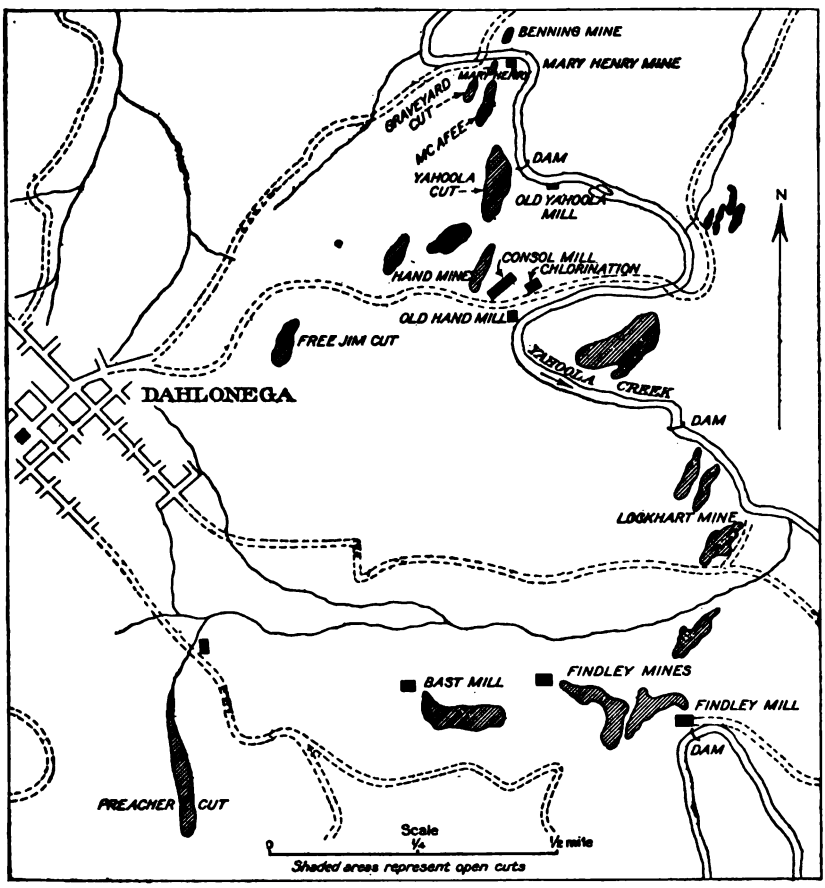


FIG. 15.—Sketch map of the vicinity of Dahlonega, Ga., showing location of mines.

the feldspar prevails over the amphibole, thus giving a lighter, greenish-white aspect to the rock. The constituents, as seen under the microscope, comprise green amphibole, chlorite, calcite, quartz, albite (?), magnetite or ilmenite, pyrrhotite, and chalcopyrite. The structure of the rock is characteristically crystalloblastic. Thorough recrystallization has taken place, and the principal mass now consists of a quartz-feldspar mosaic in which lie embedded ragged and elongated grains of hornblende, some of them inclosing small parts of the mosaic. The mosaic contains very few striated feldspar grains, but much feldspar is present, and most of it, as indicated by its optical properties, is an oligoclase, although some of it may also be albite. The chlorite has the normal characteristics of that mineral, and its occurrence renders it probable that it is wholly derived from the hornblende by

hydrochemical metamorphism. Calcite is present in compact or elongated aggregates, many of which include small parts of the quartz mosaic; it penetrates and is being penetrated by hornblende. The only mica present consists of small foils of chestnut-brown biotite embedded in the mosaic.

Of the metallic minerals, magnetite is present in elongated masses, in places intergrown with pyrrhotite and chalcopyrite. There is no pyrite, but a considerable amount of pyrrhotite, usually intergrown with smaller grains of chalcopyrite. In many places these sulphides are inclosed in calcite or in hornblende.

The most recent rock of the bed-rock series is a light-colored, coarse-grained granite, exposed at the Benning mine and at several points west of Yahoola Creek, in a westerly direction from Dahlonega.

The relations of granite to the mica schists are very clearly exposed at the Benning mine, and the contact is illustrated in Pl. VIII. The main contact, shown near the right of the plate, is somewhat indistinct for a distance of several feet, and this is due to the thorough injection of the schists near the contact plane by granitic magma, so that the rock here has the appearance of granite containing a great number of thin and dimly outlined streaks of schist. About 10 feet to the north of the contact the schist contains dikes of granite. These dikes, which are injected between the planes of schistosity, are bent and in some places contorted and have acquired a slight schistosity, as has also the main mass of the granite wherever exposed.

The Benning granite is a white, coarse, granular, imperfectly schistose rock. The schistosity is apparent chiefly by the development of sericite on incipient planes. In sections perpendicular to the schistosity the lenticular form of many of the grains indicates the pressure to which the rock has been subjected. Besides quartz and feldspar, the rock contains large flakes of biotite, 5 to 8 mm. in diameter, which, however, have mostly been converted into aggregates of muscovite. The microscope shows a granular but distinctly compressed rock. The large quartz grains are converted into aggregates of the same mineral. The feldspars, which consist of orthoclase and oligoclase in large grains, contain an abundance of straight muscovite foils, which have developed on the cleavage planes. They also contain zoisite and epidote in small crystals and grains. In places a great amount of recrystallized aggregates of quartz and feldspar mingled with muscovite have formed.

A white, coarsely granular rock, collected from the Benning mine, proved to be almost wholly composed of albite in large anhedral or roughly square grains with thin twin lamellæ. There is no other mineral present in this rock except a little muscovite in small foils and a little microperthite. This albite rock probably occurs as a dike near the granite contact.

Although the grain of the schist is somewhat coarser than usual at the Benning contact, there is little evidence of contact metamorphism, except by the development of garnets and tourmaline in the schist, as described in more detail under the heading of the Benning mine (pp. 127–128). Whether the garnet is really of contact-metamorphic origin is not certain. The same doubt applies to the tourmaline, which is present in some schists at a considerable distance from granite contacts.

PRODUCTION.

The gold deposits of the Southern States have been known for one hundred years and were probably the earliest discovered and worked within the present area of the United States. Possibly some little placer mining had been carried on by the Indians in New Mexico prior to that time, but the important placer mines of that Territory were not discovered until 1828. Between 1799 and 1830 a small amount of gold was washed in the Carolinas. In 1828 gold was discovered near Dahlonega, and in 1830 the first deposit of gold from Georgia, amounting to $212,000, was made in the United States Mint. Shortly afterwards, in 1838, a branch mint was established, which, from 1838 to 1861, coined $6,115,569. The total production of gold and silver in Georgia, from the discovery to 1900, is between sixteen and seventeen million dollars, and of this amount the largest portion has been produced by the mines of Lumpkin County, in which Dahlonega is situated. The

CONTACT OF GRANITE AND MICA-SCHIST AT BENNING MINE.

Main contact 2 feet to right of hammer. Injected zone about hammer. Granite dikes to left.

total production of the Appalachian States from 1800 to 1900 is considered to be $47,000,000. For the last few years the total annual production has been about $300,000, while the production of Georgia has varied from $130,000 to $60,000, the latter figure being recorded in 1903.

GENERAL CHARACTER OF THE VEINS.

As already pointed out by Eckel, many of the gold deposits lie on the contact either of mica schist and amphibolite or of mica schist and granite. This does not apply to all of them, however, for some, like the Jumbo and Garnet, are entirely inclosed in mica schist.

Of the three rocks, the mica schist is the oldest and the granite the youngest. The quartz veins are later than the granite and appear to exhibit a certain relationship to that rock in their occurrence. At no place are the veins located far from the granitic intrusions; even at the Jumbo mine, which is wholly in mica schist, granite outcrops only a few hundred feet away. The veins follow the schistosity in strike and dip, although at each deposit there are many stringers of quartz which cut across the division planes of the rock.

The deposits are in part "stringer leads," to use Becker's expression, and in part distinct veins, composed of a series of flat lenticular bodies of quartz, usually strictly conformable to the schistosity and following even its minor curves. The familiar, sharply cut fissures of the western veins are absent. In some cases the veins are corrugated or curved. As Becker has pointed out, all this shows that there was a certain degree of correspondence between the forces which produced the schistosity and those which opened the fissures. The quartz is, as a rule, compact, milk-white or even glassy, and shows normal coarse, hypidiomorphic vein structure without evidence of much crushing and shearing even in the veins which appear bent and curved; drusy places with projecting crystals are not uncommon; comb quartz is rare, although occurring in some narrow seams which cut across the prevalent fissures, as, for instance, in Preacher Cut. Much of the bright-yellow gold is coarse, and forms, without doubt, a primary constituent of the ore. The sulphides are relatively poor, but in the oxidized zone they have naturally contributed their quota of gold to enrich the ore. The sulphides associated with the quartz are pyrite, chalcopyrite, and zinc blende; pyrrhotite occurs sparingly. In the Benning vein magnetite occurs anhedral or in octahedral crystals and intergrown with pyrrhotite, chalcopyrite, calcite, and chlorite; pyrite is also contained in the quartz. Of gangue minerals there is some calcite or dolomitic carbonate; in many places in the Benning veins this lies along the wall, as it commonly does in California veins. Garnet, apatite, ilmenite, muscovite, dark-green mica, and green hornblende occur in the altered wall rocks of some veins, but also in places directly in the quartz. Dark-green zinc spinel or gahnite in octahedral crystals is embedded in quartz with free gold and small foils of sericite from the Rosamund vein of the Standard group.

Gahnite is a rare mineral and, like spinel, usually occurs in gneisses or as a result of contact metamorphism. It is not altogether unknown in mineral deposits, for Genth[a] describes it from the Cotopaxi mine, Chaffee County, Colo., associated with pyrite, galena, and chalcopyrite, and containing inclusions of chalcopyrite. A. G. Dana[b] mentions an occurrence of gahnite from the Rowe pyrite deposit in Massachusetts. This is a lenticular vein in gneiss, and the gahnite occurs partly in the pyrite and partly lining cavities subsequently filled with quartz. It is here associated with apatite, ilmenite, rutile, epidote, garnet, calcite, triclinic feldspar, pyrite, and sphalerite.

In the lenticular veins pay shoots occur similar to those elsewhere found in gold veins, and Mr. Joe Clement informs me that the rule in Dahlonega is that they pitch to the left of an observer standing on the croppings and looking down along the dip.

The wall rock adjoining the quartz at many places contains enough gold to be classified as an ore, though, as a rule, the principal values are considered to be contained in the quartz. In the same veins garnets, hornblende, apatite, and a green mica may develop along the quartz vein, as shown, for instance, at the Lockhart mine and several other places. The

[a] Am. Jour. Sci., 3d ser., vol. 29, 1885, p. 455. [b] Proc. Am. Phil. Soc., vol. 20, 1882, p. 397.

garnet, as already indicated by Becker, contains native gold. At other mines the alteration of the mica schist is not extensive, though the rocks next to the vein may acquire a more silvery luster, due to some additional development of muscovite in the schist. The biotite in the schist remains unaltered, as does the chlorite and feldspar. Crystals of garnet may develop in the schists near the vein. Chalcopyrite, pyrite, and pyrrhotite, probably due to vein-forming action, appear in small quantities in the wall rock, but with these magnetite or ilmenite may be associated.

As observed in the Benning vein, the alteration of the granite adjoining the veins is very slight, being limited to a slight development of chlorite along the contact. In the Jumbo mine, on the other hand, the mica schist has been altered next to the quartz seams; sericite has evidently developed at the expense of biotite, which is practically eliminated. Nor is there any magnetite or ilmenite in the altered rock, though much pyrite and rutile have developed.

All this seems to show that the veins of Dahlonega were not all formed under the same conditions. There are, on one hand, the prevailing veins like the Standard, Lockhart, and many others in which, during the vein-forming processes, biotite, hornblende, garnet, epidote, spinel, magnetite, and ilmenite were stable compounds. These again may be divided into those carrying garnets, like the Lockhart, Findley, and McAfee veins, and others in which garnet is absent, like the Benning or the Standard. On the other hand, in the Jumbo mine biotite and magnetite appear to be unstable under the influence of vein-forming solutions.

The association of minerals and the metasomatic alteration in the first of these two classes is very different from that prevailing in the California gold-quartz veins and in fact in all the principal classes of gold and silver veins of the West.

In these California veins magnetite, garnet, ilmenite, spinel, hornblende, and apatite are practically unknown as vein minerals. In the alteration by the vein solutions magnetite, feldspars, biotite, hornblende, and epidote are unstable and are converted to a fine-grained aggregate of sericite with quartz or carbonates, as has taken place in the Jumbo mine. In the prevailing class of Dahlonega mines, on the other hand, the products of alteration are such minerals as occur in areas of regional metamorphism or in contact zones, and yet the association of quartz and some calcite with native gold and pyrite, chalcopyrite, and zinc blende is unmistakably similar to that of the California veins. It may be permissible to conclude from this that the solutions in both cases were similar, but that they acted under different physical conditions. The temperatures prevailing during the deposition of the southern veins were probably much higher than those in the Cordilleran region at the levels now accessible to us in mineral deposits there exploited. Becker justly remarks that the southern veins have been subjected to long-continued erosion and that the present croppings are far below the original ones, possibly as much as 15,000 or 20,000 feet. On the other hand, in the western mines, the amount of rock removed undoubtedly falls far short of this amount.

If this conclusion is correct, it is evident that the precipitation of gold from vein-forming solutions extends over a very large vertical range. In California this range is known to be at least 3,000 feet.[a] At Bendigo, Victoria, mining has reached a depth of 4,000 feet, and at least 2,000 feet of rock have been removed by erosion. The veins still bear the general character of the California gold-quartz deposits.

It is scarcely to be expected that a brief investigation like the present one should yield any definite clews as to origin of the gold. The clustering of the veins about intrusive masses of granitic rocks is, however, a very suggestive fact which previous investigations of Dahlonega mines have not sufficiently emphasized and which is repeated in practically all known occurrences of typical gold-quartz veins. The probable great depth of deposition would also suggest that circulation of surface waters was a negligible factor, although it is conceded that the plasticity of the rocks was not so great as to preclude the existence of

[a] Lindgren, W., Gold-quartz veins of Nevada City and Grass Valley districts, California: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1896, p. 183.

open spaces of moderate size. Briefly, I am convinced that the mode of origin of the Dahlonega deposits was entirely similar to that of other auriferous quartz veins of Californian and Australian type, although, owing to physical causes, some features of their development differed. In all three cases it seems a probable hypothesis that the gold was contained in the granitic magma and that it was separated from it during the cooling process and carried to the veins in the form of solutions in magmatic water.

The study of the mode of alteration of wall rocks in different mines affords some basis for the suggestion that there may have been two epochs of vein formation in which the physical condition during deposition differed in a decided manner.

The abundance of intergrown pyrrhotite and chalcopyrite in some of the amphibolites of Dahlonega brings to mind the occurrence of deposits of such minerals at other places in the South—Ducktown, for example. In the present case these sulphides have every appearance of having been formed by the same metamorphic processes which made an amphibolite out of a diabase or diorite, and, if this is true, the chalcopyrite merely represents the concentration by aqueous agencies of the copper distributed through the rock.

DESCRIPTIONS OF MINES.

PREACHER CUT.

The pit known as the Preacher Cut, made by hydraulic work, is situated half a mile south of Dahlonega. Amphibolites, striking northeastward, prevail between this mine and the town, but near the cut mica schist is the country rock and strikes northwesterly, dipping to the northeast or southwest at angles of from 35° to 65°. This cut is about 800 feet long, extending in a southwesterly direction, 200 feet wide, and about 60 feet deep. The central part is occupied by a well-defined dike of amphibolite about 60 feet wide and gradually tapering toward the southwest. At the lower end of the cut, nearest to the town, the contacts of the amphibolite and mica schist are sharply defined and about perpendicular. The amphibolite is fairly fresh in the bottom of the cut, but elsewhere red and softened. The schistosity of the mica schists continues in imperfect development across the dike. Along both sides of the dike the schists contain numerous thin stringers of solid quartz dipping with the schistosity; there are also a few veinlets along the contact. The gold occurs to some extent in the veinlets with schist, but chiefly in the schist surrounding these stringers along both sides of the amphibolite dike. There is very little gold in the amphibolite. The schists and the quartz stringers near the contact are in places contorted and corrugated. Garnet occurs at this locality, probably associated with the quartz, but the specimens were too decomposed to ascertain this definitely. A northwestward-trending dislocation crosses the upper part of the cut. In this break or fault are several narrow quartz veinlets with fine comb structure; native gold is said to occur in these.

The peculiar feature in this mine is that the gold-bearing zone extends along both sides of the amphibolite dike in a direction perpendicular to that of the schistosity and of the auriferous veinlets. In the bottom of the cut the rocks are hard and the hydraulic process scarcely feasible, while the average values are said to be low.

CONSOLIDATED MINES.

Half a mile east-northeast of Dahlonega on the road to Yahoola River are the extensive hydraulic cuts of the old Hand properties, now owned by the Dahlonega Consolidated Gold Mining Company. Some years ago a large shaft was sunk here, near the bottom of these cuts, and a 120-stamp mill built, with a 30-ton chlorination plant and 48 Frue vanners, with the idea of mining the stringer zone on a large scale. Probably the grade proved rather low. At the present time 30 stamps are dropping.

The country rock in the Hand cuts and in the tunnels of the Dahlonega Consolidated Gold Mining Company below them is a garnetiferous mica schist, contorted in places and containing many dikes of a white, somewhat aplitic granite up to 1 or 2 feet wide, which

likewise have suffered corrugation and bending. This is probably the southerly continuation of the Benning contact zone. The schist contains stringer zones of quartz veinlets trending northeastward, and some of these zones are now mined in the tunnels just back of the mill.

STANDARD MINES.

On the east side of Yahoola River and about a quarter of a mile northeast of the Consolidated mines are the Standard mines. They consist of a series of quartz lenses known as the Weaver, Campbell, Thaloneka, and Rosamund veins. The developments are confined to tunnels and small underhand stopes. From the Rosamund vein good ore was extracted at the time of visit and milled in the Standard mill with 20 stamps. Very rich pockets are occasionally found.

The country rock is a rather coarse mica schist which close to the veins appears to contain a little more muscovite than elsewhere. It is a normal biotite-quartz schist with a small amount of magnetite, albite, and muscovite, but contains no garnet or tourmaline. A little pyrite, pyrrhotite, and chalcopyrite are present in intergrown aggregates and probably are derived from the vein solutions. The schistosity strikes N. 12° to 25° E., the dip being 35° ESE. The quartz of the veins is compact, almost glassy, and contains irregularly distributed pyrite, chalcopyrite, zinc blende, and in some cases galena, besides free gold, partly intergrown with quartz, partly with sulphides. At the time of visit a stope 25 feet long was carried down below the tunnel level on the Rosamund and extracted 7 feet wide. No values are here contained in the schist adjoining the quartz. The manager, Mr. George Bryman, states that the ore contains $20 per ton in gold; the sulphides contain $25 per ton and are thus comparatively poor.

LOCKHART MINE.

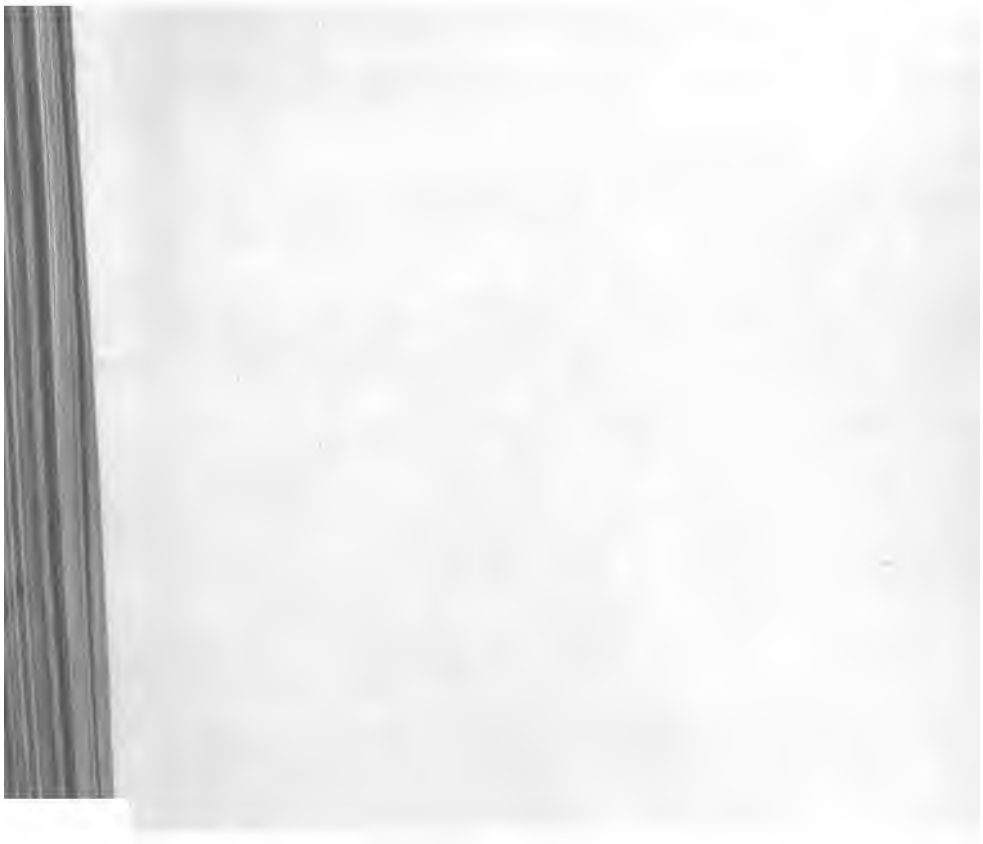
Along Yahoola River from the Standard to the Lockhart mine, amphibolites prevail with north-northeast or east-northeast strike and variable dip. Near the Lockhart mine mica schist begins, and at a fresh exposure on the river bank was noted a small lenticular vein of quartz containing a few garnets. The same mineral was also contained in the immediately adjoining schist. This stringer probably belongs to the Lockhart zone.

The Lockhart mine has been worked successfully for many years, but on a small scale. A large surface cut is situated on the west side of the river, and recently a shaft 60 feet deep has been sunk near the stream and tunnels run in a westerly direction to intersect the veins. The veins lie in a belt of normal mica schists like those described on page 120, dipping about 40° E. or NE. and very near to a mass of amphibolite which conformably underlies these schists. The ore occurs in shoots, locally called "arms," which consist of a series of lenticular quartz masses in dark-gray or black mica schist, but very close to the contact of the underlying amphibolite. The veins, like the schists, dip 30° to 40° NE. In the large cut the rocks are much decomposed and the shaft was inaccessible on account of water, but excellent exposures were seen in a small tunnel or cut about 200 feet southwest of the shaft.

As shown in fig. 16, the vein is here 7 feet wide, dips 34° NE., and consists of a number of quartz stringers more or less lenticular in shape and separated and adjoined by streaks of a very coarse-grained rock, which consists chiefly of garnet, dark-green mica, and hornblende, and which evidently represents the country rock deeply altered by the same solutions as deposited the quartz. Beyond the walls indicated in fig. 16 the rock is the normal mica schist, though the amphibolite lies a short distance in the foot. Pl. IX represents in natural size a cut and polished specimen from the vein, which well illustrates the characteristic structure. The garnets are indicated in the dark central and upper portions by the light rims of remaining polishing powder. Most of the remaining dark portion is a dark-green, almost black mica, which also in places projects its foils into the white quartz. Little specks of pyrite are contained in the dark part, while none show in the quartz. Sulphides, however, occur in the quartz and consist of pyrite, pyrrhotite, chalcopyrite,

POLISHED SPECIMEN OF ORE FROM LOCKHART MINE, DAHLONEGA.

Showing quartz with streaks of garnet, dark-green mica, and hornblende.



and galena. Much of the ore is of good grade, the samples assayed by Dr. Yeates in his report on the gold deposits of Georgia containing from $12 to $15 per ton. The average is, however, probably less than this. Most of the gold in this vein is said to appear as native metal in the reddish-brown garnets and a specimen obtained substantiates this statement.

It is very clear that the coarse-grained mixture of garnet and mica is the result of the alteration of the schist and its study presents several interesting features. Sections of the quartz show normal, hypidiomorphic, coarse-grained structure, the grains exhibiting no optical disturbance. Fluid inclusions with gas bubble and in some instances solid transparent particles also are very abundant. Embedded in the quartz lie streaks of aggregates of common green hornblende, usually in irregularly lath-like grains molded by the outlines of the quartz grains; in places radial bunches of hornblende prisms also project into the quartz. Associated with the hornblende are granular aggregates of a mineral which corresponds well to apatite; locally these are also wholly embedded in quartz. There are also small foils of muscovite and isolated similar forms of biotite. Anhedrons of pale-red garnet are inclosed in the quartz or conform to the outlines of the quartz grains. In the hornblende lie embedded scattered grains of pyrite and more abundant ilmenite. A few imperfect crystals of ilmenite are contained in the quartz grains, between which a little calcite also appears.

Other sections made from the polished specimen show large rounded crystals of garnet, with a few inclusions of green mica. The garnets are contained in a coarse aggregate of straight mica foils, with a pleochroism varying from pale green to deep leek green. The exact mineralogical position of this mica has not been ascertained. Veins similar to the Lockhart are mined at the Findley and the McAfee mines. In the McAfee the garnets are said to be smaller than in the Lockhart, but they also contain native gold.

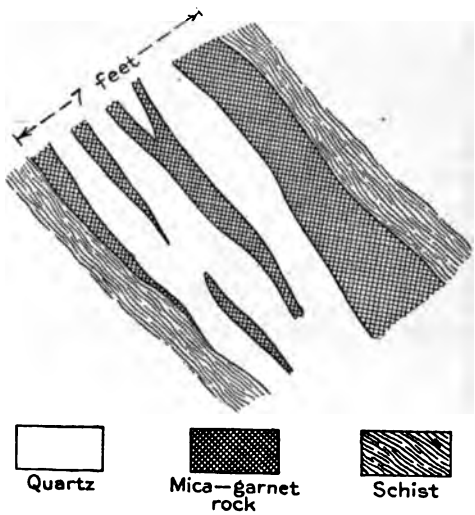


FIG. 16.—Diagram showing structure of Lockhart vein.

BENNING MINE.

The Benning mine is situated 1 mile northeast of Dahlonega, on Yahoola River. The developments are limited and consist chiefly of a large incline driven on a wide quartz lens in the mica schist within 25 feet of the granite contact, but parts of the vein are also contained in granitic dikes. The country rock is here a dark-gray glistening mica schist consisting of a quartz mosaic without much feldspar; in this are embedded dirty-brown sharply outlined foils of biotite, many of them small and straight; a smaller amount of muscovite is present in similar foils. There are also a few grains of calcite, inclosing some mosaic, and a few foils of chlorite, probably not derived from the biotite. Magnetite is distributed throughout rather abundantly and there are a few grains of pyrite and pyrrhotite. The schist also contains a few large crystals of garnet inclosing smaller masses of mosaic; a few prisms of tourmaline were noted. The whole structure is typically crystalloblastic.

Along some small stringers of quartz to the left of the granitic dike garnets have developed abundantly, but whether this quartz is of the same origin as the gold-quartz veins or represents a local quartz facies of the granite could not be definitely ascertained.

The quartz lenses which range up to several feet in width consist of coarse normal vein

quartz, with a little calcite or dolomitic carbonates, pyrite, pyrrhotite, chalcopyrite, and magnetite. The sulphides in places give a banded appearance to the quartz.

Neither schist nor granite is noticeably altered along the vein. Biotite, albite, and orthoclase from the wall rock adjoin the quartz without change.

JUMBO MINE.

The Jumbo property is situated 6 miles northeast of Dahlonega, near the Garnet mine and on Cavender Creek, which has proved auriferous up to these mines. The developments consist of several tunnels and a 60-foot shaft. The country rock is a dark brownish-gray mica schist, with curved surfaces of schistosity; it is similar to the schists already described, but contains very little black iron ore; instead, small anhedrons of pyrrhotite are present.

The surface rocks are very soft and decomposed to a depth of about 50 feet. Granite is said to outcrop a short distance away from the mine. Over a width of several hundred feet the schists, which strike N. 20° E. and dip steeply to the northwest, contain a great number of chiefly conformable quartz stringers and several good-sized quartz veins with some pyrite. Within this zone are several narrower belts from a few feet up to 50 feet in width, in which the gold values are especially concentrated. The gold has a crystalline appearance and is very fine grained.

Specimens of the ore from the shaft show that it consists of a bleached schist with more or less lenticular quartz veins having an allotriomorphic structure and containing sharply defined cubes of pyrite. The schist adjoining the veins is bleached by abundant development of sericite; it contains no garnets nor biotite, but some chlorite and many microscopic crystals of rutile. It is proposed to mine the decomposed surface rock at this mine by hydraulic methods.

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[Bulletin No. 293.]

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